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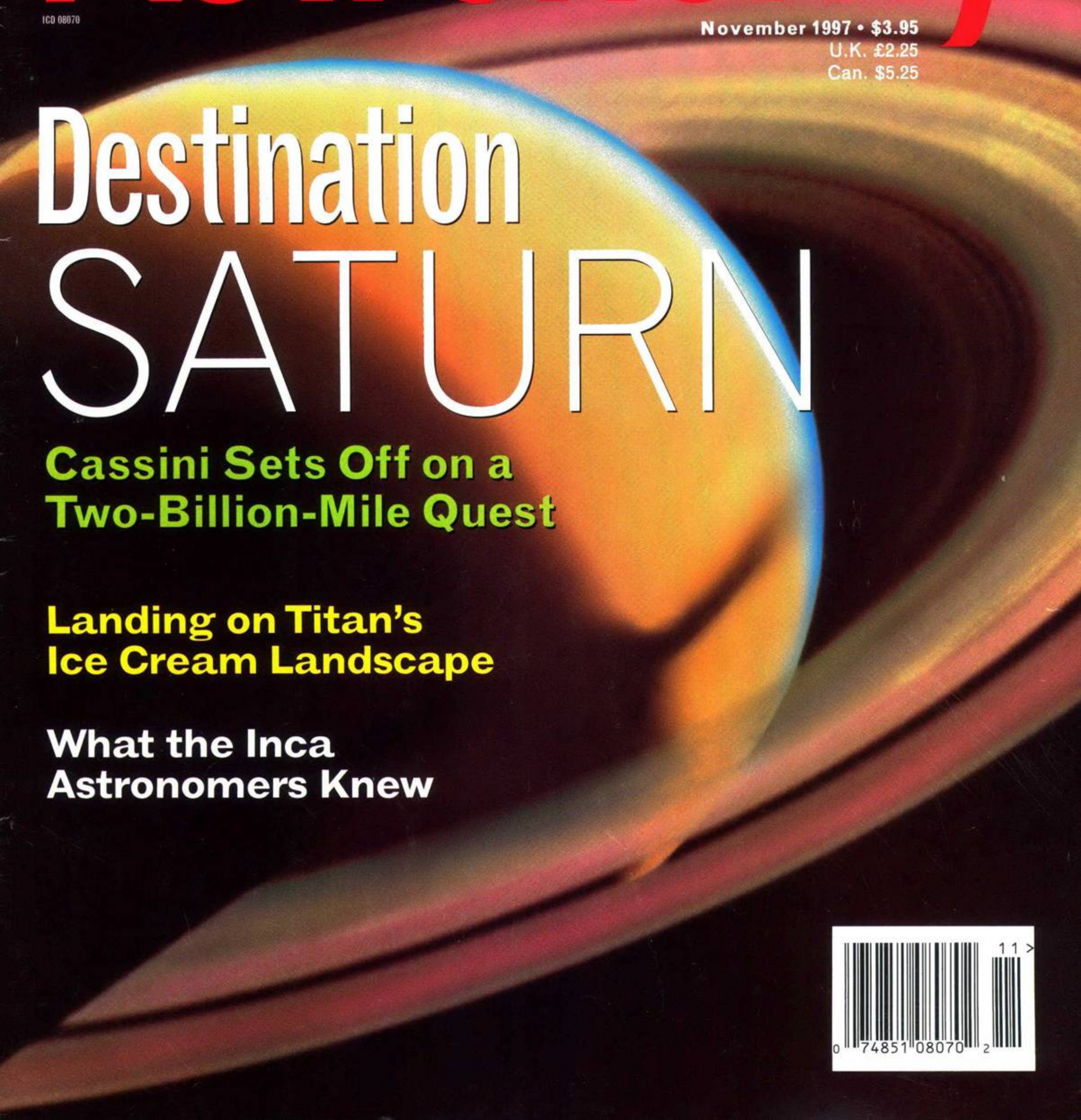

Destination SATURN

Cassini Sets Off on a Two-Billion-Mile Quest

Landing on Titan's Ice Cream Landscape

What the Inca Astronomers Knew

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LX50

Advanced technology at the most affordable prices *ever.*

■ **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel. Or use the standard-equipment 25 ft. cord to power the telescope directly from any auto cigarette lighter plug.

■ **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for full dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A. Switch speeds instantly using the speed-control button on the hand controller. Dual-axis drive rate is indicated by a red LED.

■ **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below)*. A North-South switch permits telescope operation anywhere in the world.

■ **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

■ **Massive LX200-type Fork Mounts:** Meade LX50 mounts are manufactured of the same virgin aluminum castings as Meade LX200 Schmidt-Cassegrains. Massive, rigid mountings that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications. *No competing mid-priced equatorial mountings even come close.*

SPECIFICATIONS: 7", 8", and 10" LX50's—Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; MA25mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**
7" Maksutov-Cassegrain Tube Ass'y	**1295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Large 32-character, red-backlighted display. ■ Quick 2-star alignment. ■ Four-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

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COMPUTER-CORRECTOR
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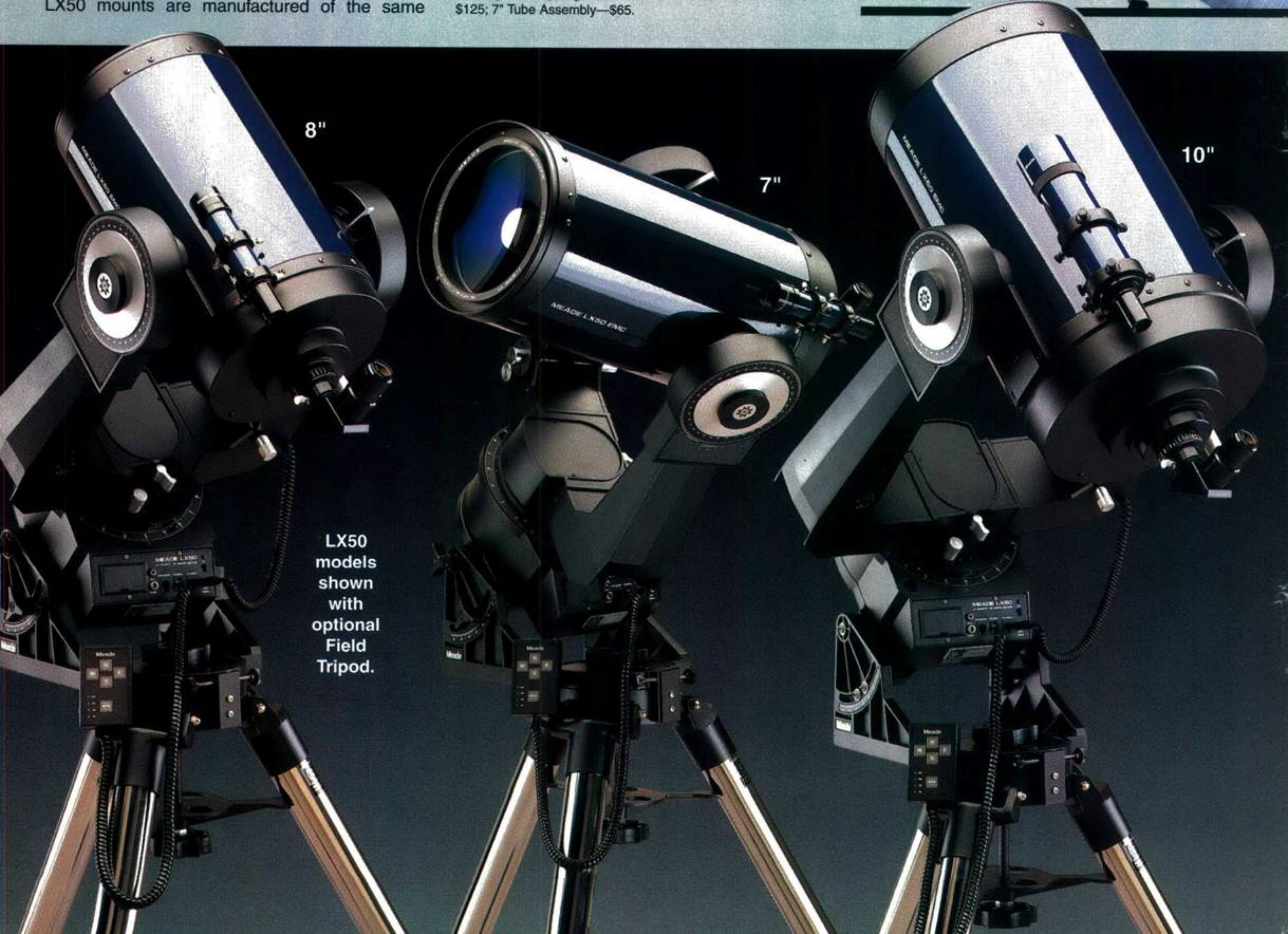
only $495!

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(right)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.



LX50 models shown with optional Field Tripod.

ADE

The largest-selling serious telescopes in the world.

LX200

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models *combined*. Consider these *standard-equipment* specifications:

■ **Superb Optics:** LX200 diffraction-limited imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.

■ **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of 64,359 objects in the onboard database, *to a precision of one arc-minute or better.*

8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

■ **Meade LX200 High-Precision Pointing™** is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat that no other telescope priced under $40,000 can accomplish.*

■ **Permanently-Programmable Smart Drive™** routinely achieves 5 arc. sec. periodic error, an observatory standard.

■ **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.

■ **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The optional #1812 Electronic DC Adapter (a compact 4 oz. unit) allows for field powering directly from an automobile cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8"
7"
10"
12"
MEADE LX200 EMC

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Prices shown are suggested U.S. mail-order retail prices.

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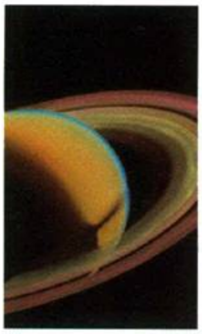

COVER PHOTO: JPL/NASA

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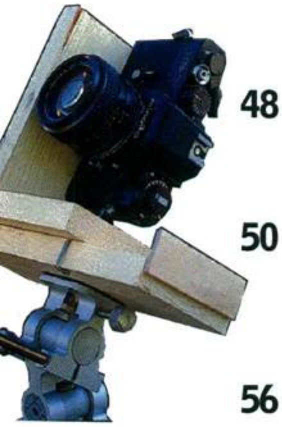

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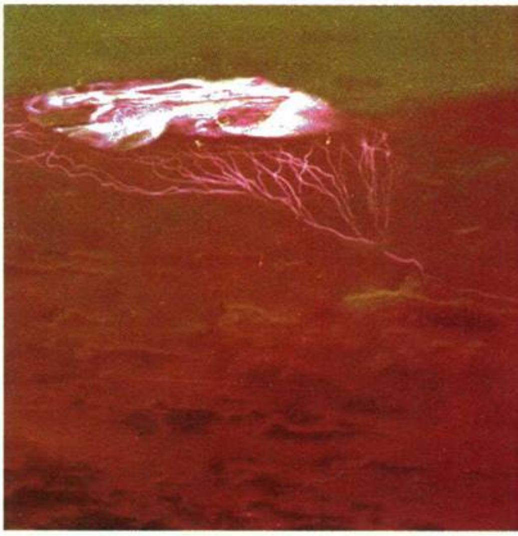

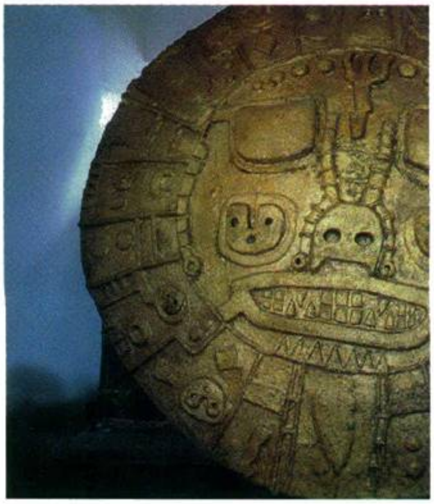

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Dave Hardy

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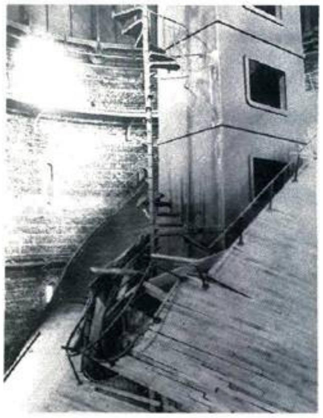

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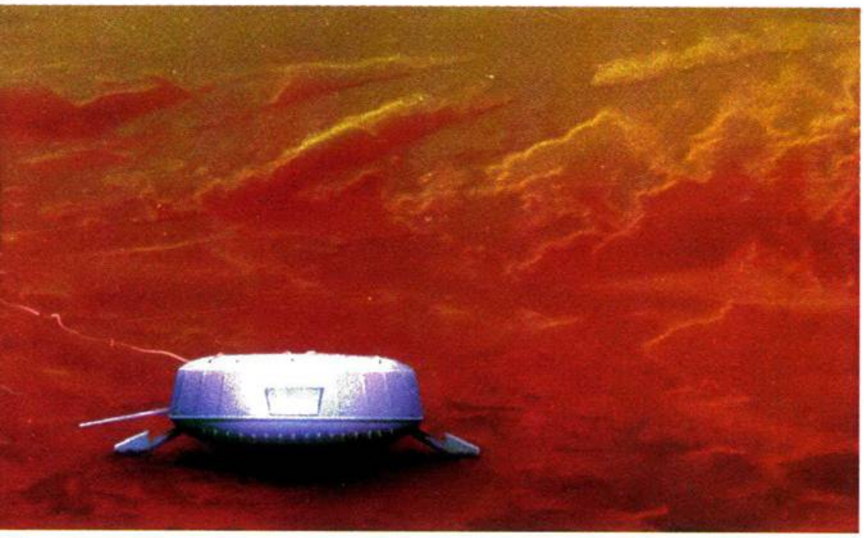
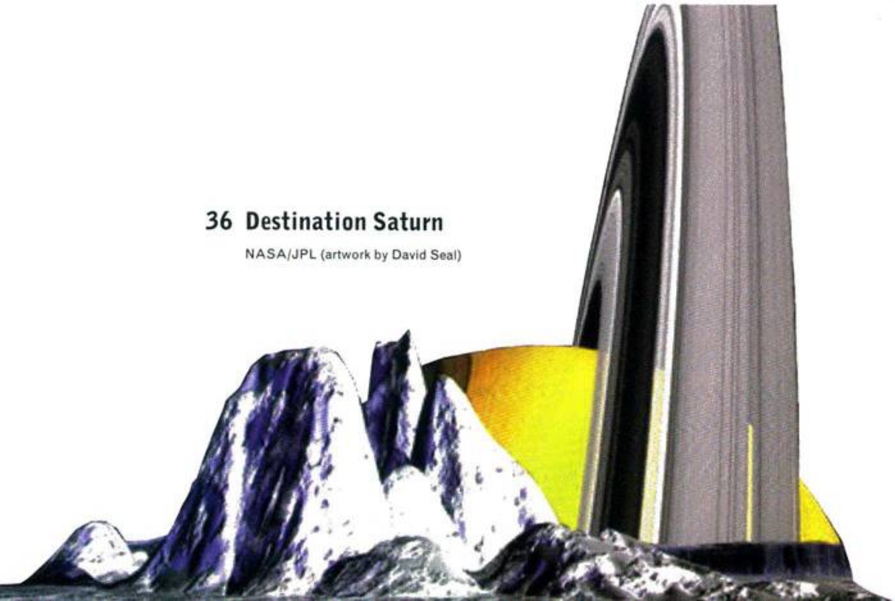


42 Landing on Titan's Ice Cream Landscape NASA/JPL



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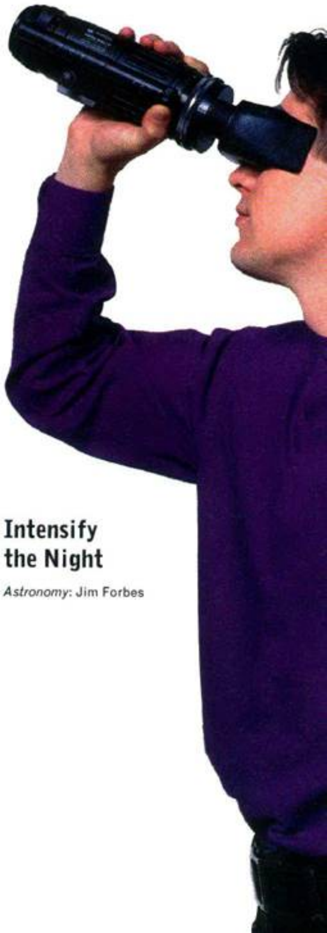
NASA/JPL (artwork by David Seal)



84 Intensify the Night

Astronomy: Jim Forbes

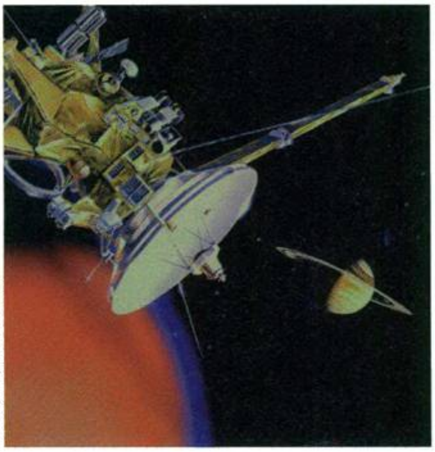
BEHIND THE SCENES

BY BONNIE BILYEU GORDON

Setting Off for Saturn

The last two years have been banner ones for NASA, years that could change the agency's fortunes for some time to come. Martian rocks and rovers have engendered a public interest in space exploration that's been palpably lacking for at least a decade. And public enthusiasm almost always assures Congressional support.

Nothing NASA has done so far this year, however, or even in the last decade, matches in ambition the Cassini-Huygens launch scheduled for early autumn. Cassini will take a clever but circuitous route to Saturn, a trip that will take seven years and rely on four gravitational boosts from other planets (see "Bound for the Ringed Planet," page 36). If it succeeds, the mission should bring us spectacular news about Saturn, its interior structure, its rings, its magnetic field, and its intense radiation belts. Cassini also will closely study eight of Saturn's 18 moons. Its imagers will be able to focus on incredibly small objects on some of the moons, objects smaller than an average American house. So if such a house exists, Cassini could find it. The satellite also will launch Huygens, a probe that will drop through Titan's murky atmosphere and land on its surface. Some researchers have high hopes about what the lander will find on the dark moon of Titan (see "Destination Titan," page 42).


NASA/JPL/Michael Carroll

Cassini will arrive at Saturn in just 7 years.

Cassini is the biggest, most sophisticated interplanetary spacecraft NASA has ever launched. If scientists tried to get something like this funded by Congress today, they would be laughed out of D.C. NASA's administrator Dan Goldin, an outspoken proponent of faster, better, cheaper missions, calls the big, bold Cassini project "Battlestar Galactica." It will be the last of the big science interplanetary missions that were planned in the 1970s and 1980s, and no others are on the boards.

Whatever you call Cassini, you have to recognize that it will carry a variety and sensitivity of instruments that can't be matched by less expensive projects. It carries a battery of tools: an imager, a magnetometer, five spectrometers, and five other instruments. If the Cassini imager picks up something interesting, other tools can be quickly activated for follow-up studies. And Cassini carries the Titan probe.

The ongoing $280-million Mars Pathfinder is revealing that the smaller missions promoted by Goldin and NASA can capture both good science and great public affection. But these missions represent a whole different category of spacecraft and science; they are opening much smaller, less resistant windows on the solar system. As NASA begins its last big interplanetary expedition, *Astronomy* intends to pay careful attention to the adventure and the results. Stay with us for the ride.

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MEADE 8" LX10

Add the optional LX10 Declination Motor for dual-axis corrections at 2x.

Meade 8" LX10
Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

All the optical performance of Meade 8" LX50 and LX200 Schmidt Cassegrains...for only *$995!*

For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *No other similarly-priced 8" Schmidt-Cassegrain offers such a range of standard features* — or such a range of important options for special applications. *Standard-equipment includes:*

Super Multi-Coated Optical System: The LX10 includes the *exact same* 8" Schmidt-Cassegrain optical tube assembly as more expensive Meade 8" LX50 and LX200 models. Super multi-coatings (not available even as an *option* on competing 8" telescopes) are included with every LX10 optical system, for the highest levels of light transmission and image contrast.

Equatorial Fork Mounting: The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power applications of the telescope, or for photographic or CCD imaging. Ball bearings on the polar axis complement the precise action of the internal worm gear system.

Cordless, DC-Powered Electronic Motor Drive: A drive system that includes an electronically-regulated DC servo motor for automatic *sidereal-rate* tracking. The drive is powered by four AA-size batteries that fit conveniently through the telescope's control panel; battery life is in excess of 50 hours.

Worm-Gear System: The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging.

Hand Controller: Essential for micro-guiding the telescope during long-exposure astrophotography, the LX10's pushbutton hand controller enables precise corrections in R.A. at 2x speed. With the optional electric Declination motor added to the telescope, the hand controller is functional at 2x speeds on both telescope axes. Both the standard-equipment hand controller and the optional electric Declination motor plug into the telescope's control panel.

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); MA25mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions.
$995. (+ $65 packing & shipping in the 48 states)

LX10 Field Tripod	**195.**
LX10 Electric Declination Motor System	**85.**
#2014 Magellan I Telescope Computer System for LX10, with 12,218-object database	**375.**

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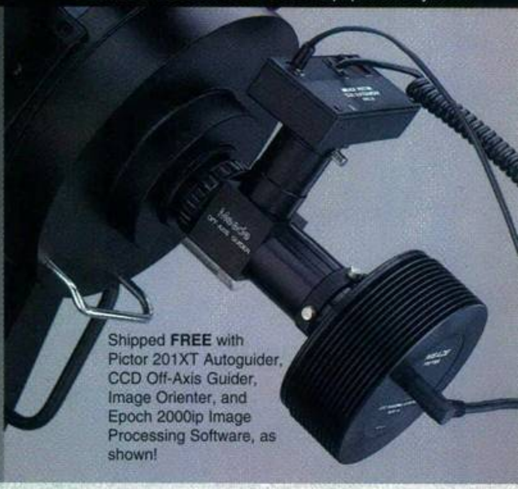

Shipped **FREE** with Pictor 201XT Autoguider, CCD Off-Axis Guider, Image Orienter, and Epoch 2000ip Image Processing Software, as shown!

Revolutionary Meade Pictor CCD's are now the world's largest-selling autoguiders and imagers for the amateur astronomer. No other electronic imaging systems offer such an incredible range of capabilities at such amazing price levels. At only **$495** the **Pictor 208XT** produces on the PC display fine, high-resolution 8-bit images *in seconds* of the Moon and planets, or, in 2 or 3 minutes, of thousands of deep-space objects. At **$695** the **Pictor 216XT** enables advanced 16-bit imaging and is *by far* the finest autoguider/imager ever made available at under-$1000. At **$1695** the **Pictor 416XT** permits professional-level imaging capability for the amateur astronomer: an electronic camera capable of producing with amateur telescopes images of the Moon, planets, and deep-space that match or exceed the photographic images obtained with many observatory telescopes. All models are available for immediate shipment. ***For complete information on Meade CCD imaging systems write, call, or fax for your free copy of the 94-page Meade 1997 General Catalog.***

Pictor 208XT images *(top to bottom):* Ring Nebula (M57), 25" reflector, Jack Newton; Galaxy (M81) in Ursa Major, 12" LX200, Scott Roberts; Trifid Nebula (M20), 8" LX200, John Hoot.

Pictor 216XT images: Whirlpool Galaxy (M51), 12" LX200, John Hoot; Globular Cluster (M13), 25" reflector, Jack Newton; Galaxy (M83) in Hydra, 12" LX200, Scott Roberts.

Pictor 416XT images: Crab Nebula (M1), 25" reflector, Jack Newton; Jupiter, 10" LX200 with Stellar Products AO-2 seeing adapter, Dr. Donald Bruns; Moon (crater Plato), 16" f/6 reflector, Dr. Donald Parker.

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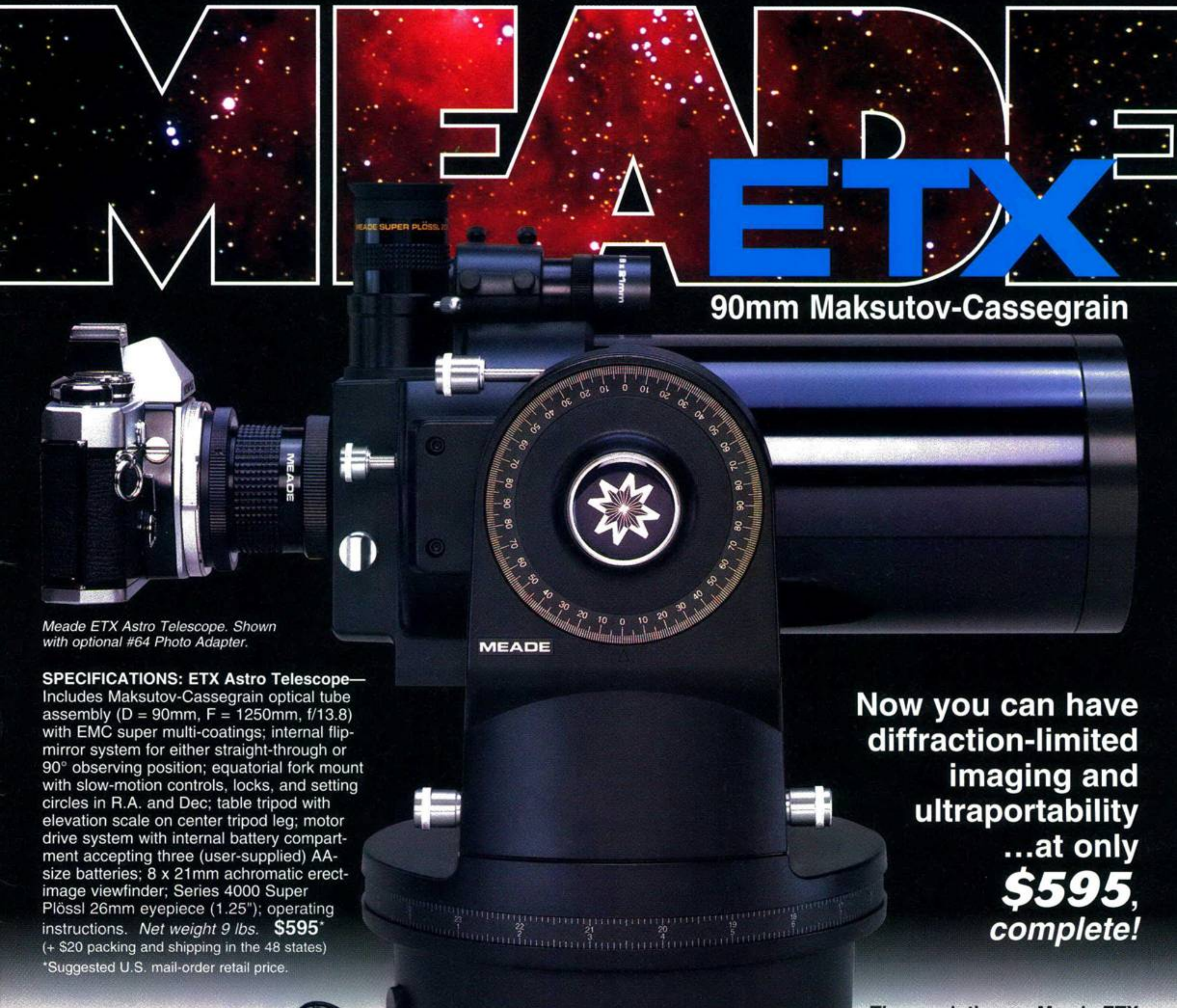
MEADE ETX

90mm Maksutov-Cassegrain



Meade ETX Astro Telescope. Shown with optional #64 Photo Adapter.

SPECIFICATIONS: ETX Astro Telescope— Includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; equatorial fork mount with slow-motion controls, locks, and setting circles in R.A. and Dec; table tripod with elevation scale on center tripod leg; motor drive system with internal battery compartment accepting three (user-supplied) AA-size batteries; 8 x 21mm achromatic erect-image viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); operating instructions. *Net weight 9 lbs.* **$595***
(+ $20 packing and shipping in the 48 states)
*Suggested U.S. mail-order retail price.

Now you can have diffraction-limited imaging and ultraportability ...at only *$595*, *complete!*

The revolutionary Meade ETX goes anywhere with you at a moment's notice and presents the finest optical images ever made available in an ultraportable telescope.

Optical System: Manufactured at the Meade Irvine, California facility, ETX diffraction-limited optics produce images so high in contrast, brightness, and resolution that the ETX consistently outperforms telescopes of much larger apertures. **Equatorial Fork Mount:** Precise polar alignment in *seconds*, just by extending the center tripod leg to read your latitude on the inscribed scale. **Cordless Motor Drive:** The internal drive system operates from 3 AA-size batteries that power the motor drive for more than 50 hours. A North-South switch permits operation anywhere in the world. **Flip-Mirror System:** Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter. **Standard accessories** include a Series 4000 Super Plössl 26mm eyepiece and 8 x 21mm erect-image viewfinder.

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STARFINDER DOBSONIANS

No other competing Dobsonians include this listing of *standard-equipment* features:

Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass: Unlike the plate glass optics of other Dobsonians that can become thermally unstable, all Meade Dobsonian optics are made of Grade-A fine-annealed Pyrex glass — the exact same professional-quality optics used on Meade Starfinder Equatorials.

Rigid, Durable, Beautiful Dobsonian Mountings, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the quick location and easy tracking of celestial objects.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

Multi-Coated MA25mm Eyepiece (1.25"): The Meade Modified Achromatic 25mm eyepiece yields sharp, high-resolution imaging to the field edge.

5 x 24mm Viewfinder: Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

Optical Tubes: Starfinder Dobsonians include the same strong, spiral-wound Sonotube™ optical tubes used on Starfinder Equatorials *(right),* tubes with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! *Meade Starfinder Dobsonians and Equatorials are the largest-selling Newtonian reflectors of their apertures in the world.* Every Starfinder model opens up the skies to an extremely wide range of serious visual observing; all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography, and even for limited deep-space photography.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

Dobsonian Deluxe Accessory Package only $49.95!

Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

- 1 - **Meade #77 2" Giant Rack-and-Pinion Focuser,** with machined aluminum eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*
- 1 - **Meade #637 6 x 30mm Achromatic Viewfinder,** with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*
- 3 - **Meade MA9mm, 12mm, and 25mm** multi-coated eyepieces, 1.25" barrel — eyepieces for the full range of lunar, planetary, and deep-space observing. *(reg. $37.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $223.75!

Meade Magellan I Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes the following objects:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

MEADE
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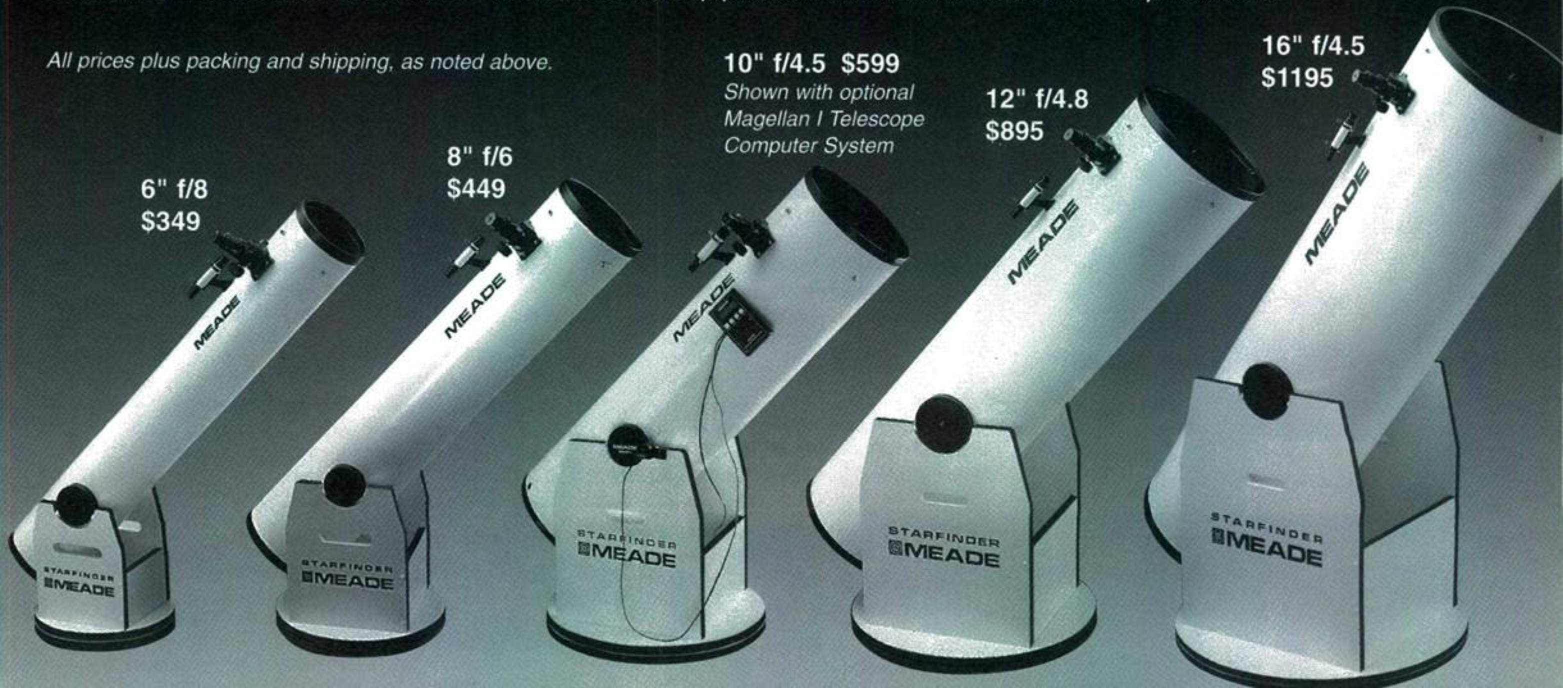
MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple.

#2010: for Meade Starfinder Dobsonian
6", 8", 10", 12.5", or 16" . . . . $295.
Packing & shipping in the 48 states—$15.

STARFINDER DOBSONIAN TELESCOPES ***Shown with standard-equipment 5 x 24mm viewfinder and 1.25" rack-and-pinion focuser.***

All prices plus packing and shipping, as noted above.



6" f/8
$349

8" f/6
$449

10" f/4.5 $599
Shown with optional Magellan I Telescope Computer System

12" f/4.8
$895

16" f/4.5
$1195

MEADE STARFINDER EQUATORIALS

DC-powered drive systems for fully automatic tracking, and a wide range of standard-equipment features:

Professional-Grade Optical System: Includes hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System! Provides fully automatic tracking of celestial objects. Operates for more than 50 hours from 6 (user-supplied) AA-size batteries. Control panel also permits powering the telescope from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 2" giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 2" and 1.25" eyepieces.

Accessories and Components: #637 6 x 30mm viewfinder with wide 7° field; multi-coated MA25mm eyepiece (1.25"); strong, durable, spiral-wound optical tube with attractive white finish.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 2" giant focuser.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

Meade Magellan Telescope Computer Systems

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TELESCOPE COMPUTER SYSTEM

Magellan I: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page).*

#2011: for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10" . . . . $295.
#2012: for Meade (DC-powered) Starfinder Equatorial 16" . . . . 295.

MEADE
MAGELLAN II
COMPUTER-CORRECTOR
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Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for (DC-powered) Starfinder Equatorial 6", 8", 10" . . 495.
#2019: for (DC-powered) Starfinder Equatorial 16" . . . . 595.

Packing & shipping in the 48 states: Magellan I–$15, Magellan II–$20.

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy 2 additional multi-coated eyepieces, MA9mm and 12mm, ***for a total of $29.95!*** *Purchased separately, the 2 eyepieces sell for $75.90.*

The fullest exposition of Meade astronomical telescopes, CCD imagers, and telescope accessories is contained in the 94-page Meade 1997 General Catalog.

Write, call, or fax Meade Instruments for your free copy!

To Order: Contact your authorized Meade Advanced Products Mail-Order Dealer, below. Prices shown are suggested U.S.A. mail-order retail prices.

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.
CALIFORNIA TELESCOPE CO., Burbank, CA.
Orders & Information: 818-505-8424.
FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.
LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.
OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.
POCONO MOUNTAIN OPTICS, Moscow, PA.
Orders: 800-569-4323; Info.: 717-842-1500.
RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.
SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 312-332-2000.
Canada:
EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.
KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

ADVANCED PRODUCTS DIVISION
Meade Instruments Corporation
World's Leading Manufacturer of Astronomical Telescopes for the Serious Amateur
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FAX: (714) 756-1450 ☐ *www.meade.com*

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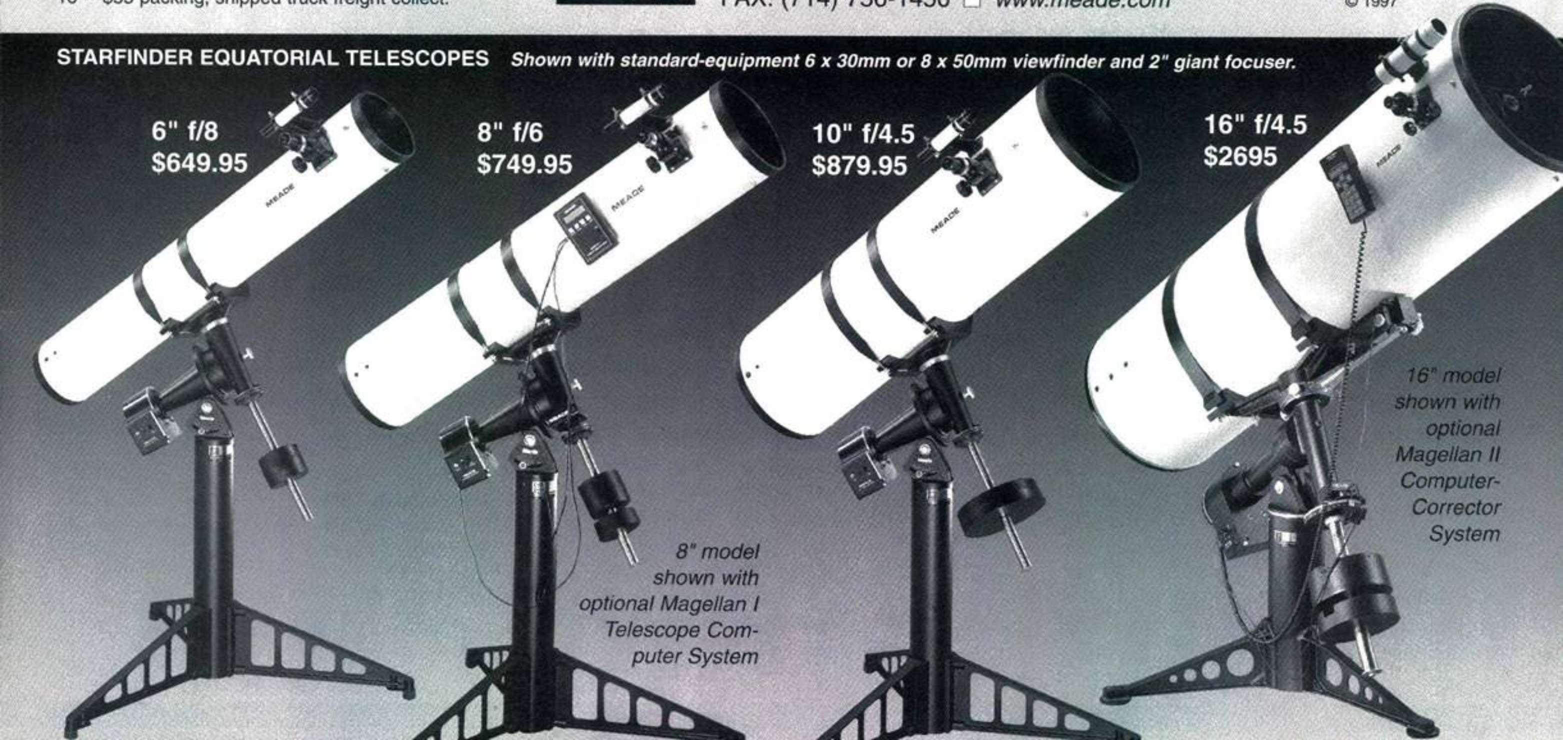

STARFINDER EQUATORIAL TELESCOPES ***Shown with standard-equipment 6 x 30mm or 8 x 50mm viewfinder and 2" giant focuser.***

8" model shown with optional Magellan I Telescope Computer System

16" model shown with optional Magellan II Computer-Corrector System

MEADE
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127ED/APO EMC
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Meade
LXD 650
U.S.A.
Meade

Meade Model 127ED:
5" *ED* Apochromatic Refractor.
Shown with optional #1697
Computer Drive System.

Background image: **the Omega Nebula (M17) —**
A 5-minute image by Jack Newton using the
Meade 7" *ED* Apochromatic Refractor and Meade
Pictor 1616 CCD Imager.

ED APOCHROMATIC REFRACTORS

"This is the best black-and-white CCD image of M17 that I have ever taken with any telescope. I just couldn't believe that this could be done in a 5-minute shot with a CCD camera and a 7" refractor. I'm amazed at how the telescope performs, even against my own 25" Newtonian." **—Jack Newton**

Fortunate indeed is the observer with a Meade *ED* Apochromatic Refractor at his or her disposal, for these are professional-class instruments capable of serious research. *Observe* structural detail and color variations within Jupiter's Red Spot and at the boundaries of 8 to 10 cloud belts; resolve all three of Saturn's main rings and substructures within the rings themselves. *Simply put, if you're looking for the finest, textbook-perfect, ultra-high-resolution, high-contrast imaging of the skies that astronomical instrumentation, of any type, can provide, then a Meade ED Apochromatic Refractor is for you.*

Use the massive Meade **LXD 650** (4", 5") or **LXD 750** (6", 7") equatorial mounts in conjunction with the optional **#1697 Computer Drive System** to slew the telescope across the sky and computer-point the instrument, automatically, *to a precision of one arc-minute.* ***Meade LXD mounts are the only commercially-available German-type mounts capable of such a feat.*** Actuate any of 9 pushbutton-controlled drive speeds (from 2x photoguide to 8°/sec. fast-slew) on both axes, automatically, to locate and center any object directly from its input R.A. and Dec. Or use the onboard database for even faster object centering. Included with the #1697 CDS, the Meade **Smart Drive**™ assures the extremely low periodic error essential to research-level photographic or CCD imaging.

More than 40 Meade optional accessories are available to suit virtually any observing, photographic, or CCD imaging requirement.

Supplied complete per catalog specifications:

4" f/9 Model 102ED	**$2795.**
5" f/9 Model 127ED	**3295.**
6" f/9 Model 152ED	**4995.**
7" f/9 Model 178ED	**5995.**
#1697 Computer Drive System	**795.**

Packing and shipping in the 48 states: 4"—$105; 5"—$125; 6"—$185; 7"—$215.

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MEADE
EYEPIECES AND ACCESSORIES

Series 4000™ Super Plössls 52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (3.45)
32mm (52°); **40mm** (44°)	each:	**99.95** (3.79)
56mm (52°; 2")		**199.95** (5.48)

Series 4000™ Ultra Wide Angle 84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (3.94); **6.7mm: 199.95** (3.94); **8.8mm** (1.25"/2"): **239.95** (5.87); **14mm** (1.25"/2"): **299.95** (6.28)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

f/6.3 FOCAL REDUCER/FIELD FL

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (3.60)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (3.45)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (3.45)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (3.45)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930,** each: **$99.95** (5.87)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.45)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (3.45)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (3.45)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.29)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (2.98)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (2.98)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (2.98)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.29)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (4.27)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (3.45)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. 1.25" **Batteries included.** **$99.95** (3.45)

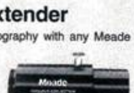
As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (3.45)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (2.98)

Variable Tele-Extender



For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (2.98)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (4.27)

Series 4000™ Super Wide Angle 67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (3.94); **18mm: 149.95** (3.94); **24.5mm: 179.95** (4.68); **32mm** (2"): **239.95** (5.87); **40mm** (2"): **299.95** (6.28)

Series 3000™ Plössls 50° field; multi-coated

The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)
5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.45)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (3.45)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (3.85)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (3.94)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (3.45)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (3.85)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (3.94)

Series 3000™ Plössl 40mm 44°

An excellent complement to the Series 3000 Plössls above, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, **multi-coated.** Barrel dia. 1.25"; threaded for filters. Apparent field: 44°.

$79.95 (3.79)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (2.98)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (2.98)

HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE CO., Burbank, CA.
Orders & Information: 818-505-8424.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

POCONO MOUNTAIN OPTICS, Moscow, PA.
Orders: 800-569-4323; Info.: 717-842-1500.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 312-332-2000.

Canada:
EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

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Model 230: 60mm Altazimuth
Refractor — **$199**

Model 285: 60mm Equatorial
Refractor — **$299**

Model 390: 90mm Altazimuth
Refractor — **$499**

Model 395: 90mm Equatorial
Refractor — **$599**

Model 4500: 4.5" Equatorial
Reflector — **$399**

Write, call, or fax Meade Instruments for your free copy of the 94-page Meade 1997 General Catalog.

Prices shown are suggested U.S. mail-order prices.

Meade® $175 Observer's Package: only *$24.95* with telescope purchase!

Use the **Meade Observer's Package** to enhance the versatility and performance of your Meade telescope. *Priced separately at **$178.80**, the Observer's Package is available at only **$24.95** for a limited time, when purchased with any Meade telescope on this page,* and includes the following important astronomical accessories:

	Meade #126 2x Barlow Lens (1.25"). A high-resolution, multi-coated achromatic Barlow; doubles all eyepiece powers.	**$47.95**
	Meade Modified Achromatic (MA) 12mm Eyepiece. Ideal mid-range magnification for the Moon and planets; multi-coated.	**37.95**
	Meade Star Navigator™ Sky Software. Windows-based software that displays over 10,000 galaxies, nebulae, star clusters, and planets on your PC	**79.95**
	Meade Moon Filter. Threads into all Meade 1.25" eyepieces; reduces glare, increases contrast of lunar features.	**12.95**

Total Package Price if purchased separately: **$178.80**

To obtain your Meade Observer's Package:

1. Purchase one of the five Meade telescopes on this page from a Meade dealer of your choosing, between September 1 and December 31, 1997.
2. Send a copy of your dealer's invoice, along with your check for $24.95, or include your VISA or MasterCard number, to Meade Instruments Corp., 16542 Millikan Ave., Irvine, CA 92606.

Requests for the above offer must be received by January 31, 1998. Offer valid only in the U.S.A. and Canada. Please allow 30 days for delivery.

Meade astronomical telescopes and accessories are available from over 500 authorized dealers in the U.S.A. and Canada, including the following authorized Meade Advanced Products Mail-Order Dealers:

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.
CALIFORNIA TELESCOPE CO., Burbank, CA.
Orders & Information: 818-505-8424.
FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.
LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.
OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.
POCONO MOUNTAIN OPTICS, Moscow, PA.
Orders: 800-569-4323; Info.: 717-842-1500.
RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.
SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 312-332-2000.

Canada:
EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.
KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

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MEADE 102/ACHR EMC
MEADE 102ED/APO EMC
MEADE 203/SC EMC
Meade
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(top) Model 102ACHR/500:
4" f/9 Achromatic
Refractor — **$995**

(left) Model 102APO/500:
4" f/9 *ED* Apochromatic
Refractor — **$1695**

LXD 500 Series

Imagine yourself at the controls of a Meade LXD 500 - series telescope, ready for an extremely wide range of advanced photo-visual applications. Each instrument includes the all-new Meade LXD 500 equatorial mounting, with dual-axis bronze worm gears, engraved setting circles, and micrometric controls in RA and Dec. as well as for azimuth and polar elevation alignment. Choose from among three models the one that's right for your budget and observing requirements.

For complete details send for your free copy of Meade Bulletin 500.

Prices are for **complete** astronomical telescopes, as shown, including optical tube assembly, LXD 500 equatorial mounting, rigid aluminum tripod, and a full complement of accessories:

Model 102ACHR/500: 4" f/9 Achromatic Refractor	**$ 995**
Model 102APO/500: 4" f/9 *ED* Apochromatic Refractor	**1695**
Model 203SC/500: 8" f/10 Schmidt-Cassegrain	**1295**
#1701 Single-Axis RA Drive System	**145**
#1702 Dual-Axis Drive System, with 4-speed (2x, 8x, 16x, 32x) hand control	**195**
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#812 Polar Alignment Finder	**49**

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A TALKING BACK
FROM OUR READERS

Why Readers Turn to *Astronomy*

I thoroughly enjoyed the July issue's articles on cosmology ("Something Instead of Nothing" and "Inflating the Cosmos"). As a subscriber for many years, I've always thought you do a better job of covering these topics than your competitor. I plan to get my hands on books by the authors of those articles in order to expand my own knowledge of these subjects. Keep the cosmology coming! — *Jack Rounds, Tyler, Texas*

In the past, I have subscribed to *Scientific American*, looking for articles on cosmology, quantum physics, and, of course, astronomy. I was very often disappointed by having to weed through the other stuff to get to the "juicy" stuff. With your change in format, I get it all. I'm not a "stargazer" because I like to look at (very) deep-sky objects and there are amateur and professional astronomers who do that much better than I. But I like to hear how our new technology and knowledge helps us understand the universe in which we live. — *Don Beadle, Victoria, Texas*

I believe the main interest of your readers is the pursuit of the hobby of astronomy. The main activities of that hobby are observing, astrophotography, and the purchase, making and modifying of amateur equipment. I would recommend that the vast majority of the magazine be devoted to these topics, rather than professional astronomy, cosmology, or space research. — *Alan Adler, New York, New York*

Religion Versus Science: Who Cares?

This is in response to the letter from John Deering that appeared in the July 1997 issue of *Astronomy* regarding science and religion. Mr. Deering urges you to consider covering the science versus religion issue, presumaby with the motive of exposing those who would attempt "road blocks to learning" vis-á-vis the big bang theory, etc. I implore that *Astronomy* not engage itself in this issue!

As both a Christian and an amateur astronomer, I am intensely interested in the "science vs. religion" (a.k.a. "Creationism vs. Evolution") debate. Having read extensively on the subject, I am convinced of two things: (1) nobody knows with complete certainty how the universe came to be, and (2) those on both sides of the debate are so diametrically opposed to each other's model that no real progress is being made to distinguish what is factual from what is farcical.

Frankly, I'm fed up with creationists and their evolutionary-bashing model — and with evolutionists and their model, which bashes the premise of design, particularly divine design. I subscribe to *Astronomy* to read about, well, astronomy. I don't subscribe to read about creationists who think evolutionists are godless fools and evolutionists who think creationists are unscientific dolts.

Please consider not compromising the pages of *Astronomy* by accommodating the rantings and ravings of blathering scientists and religious literalists who think that the way to reach the truth is to insult each other's intelligence. I'd like to see an occasional specialty article addressing – in comparative form – the details of each of the two basic models for the purpose of giving readers something to think about, but not for the purpose of inflaming the fears of people like Mr. Deering. — *Michael Gregory, Albany, New York*

The Longest Journey

To my knowledge, no one came from as far away as I did to witness the total solar eclipse in Siberia on March 9, 1997. I had to travel half the world from my native Uruguay in South

(cont. on p. 21)

Perez de Paula traveled around the world to see a total eclipse of the sun.

Rubén Rodolfo Perez de Paula

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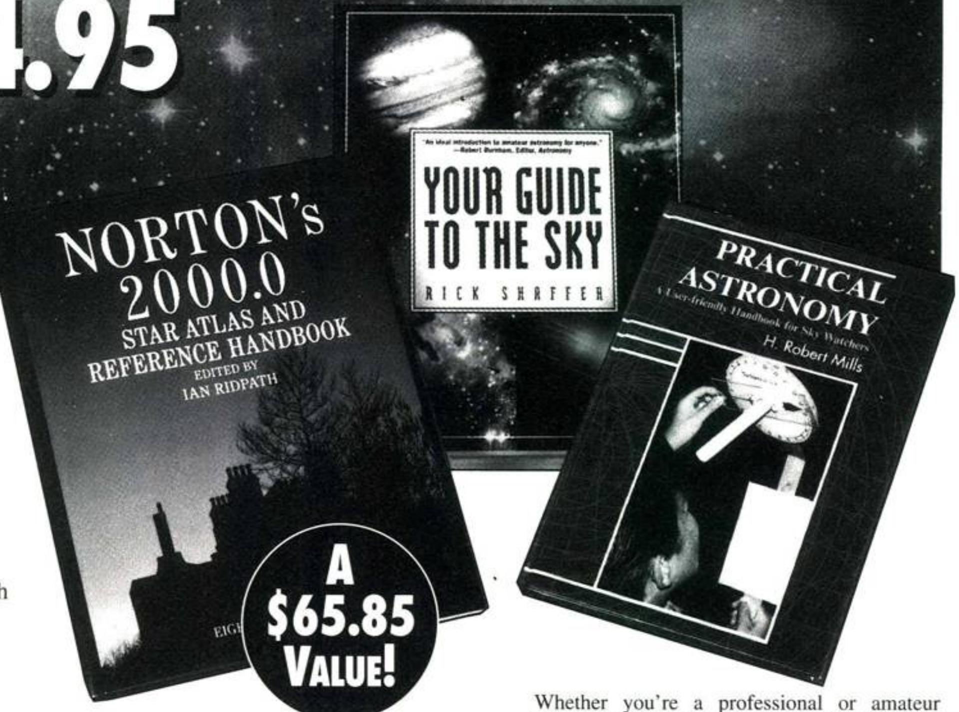
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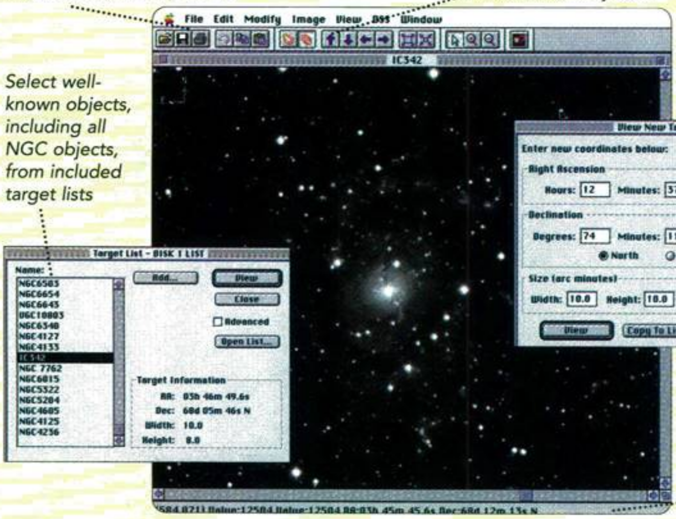

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The show was wonderful despite the −20° C temperatures. I saw Venus and Mercury clearly alongside the sun (my first-ever glimpse of Mercury). I also saw snowfall for the first time in my life. And Comet Hale-Bopp shining over the frozen Moscow River was an exceptional bonus.

The eclipse chasers were almost exclusively American, except for me and a couple of Canadians and the Italian astronomers we found in Chita. My trip was possible thanks to the tours advertised in your magazine. Thanks! — *Rubén Rodolfo Perez de Paula, Montevideo, Uruguay*

Sexism Strikes Again

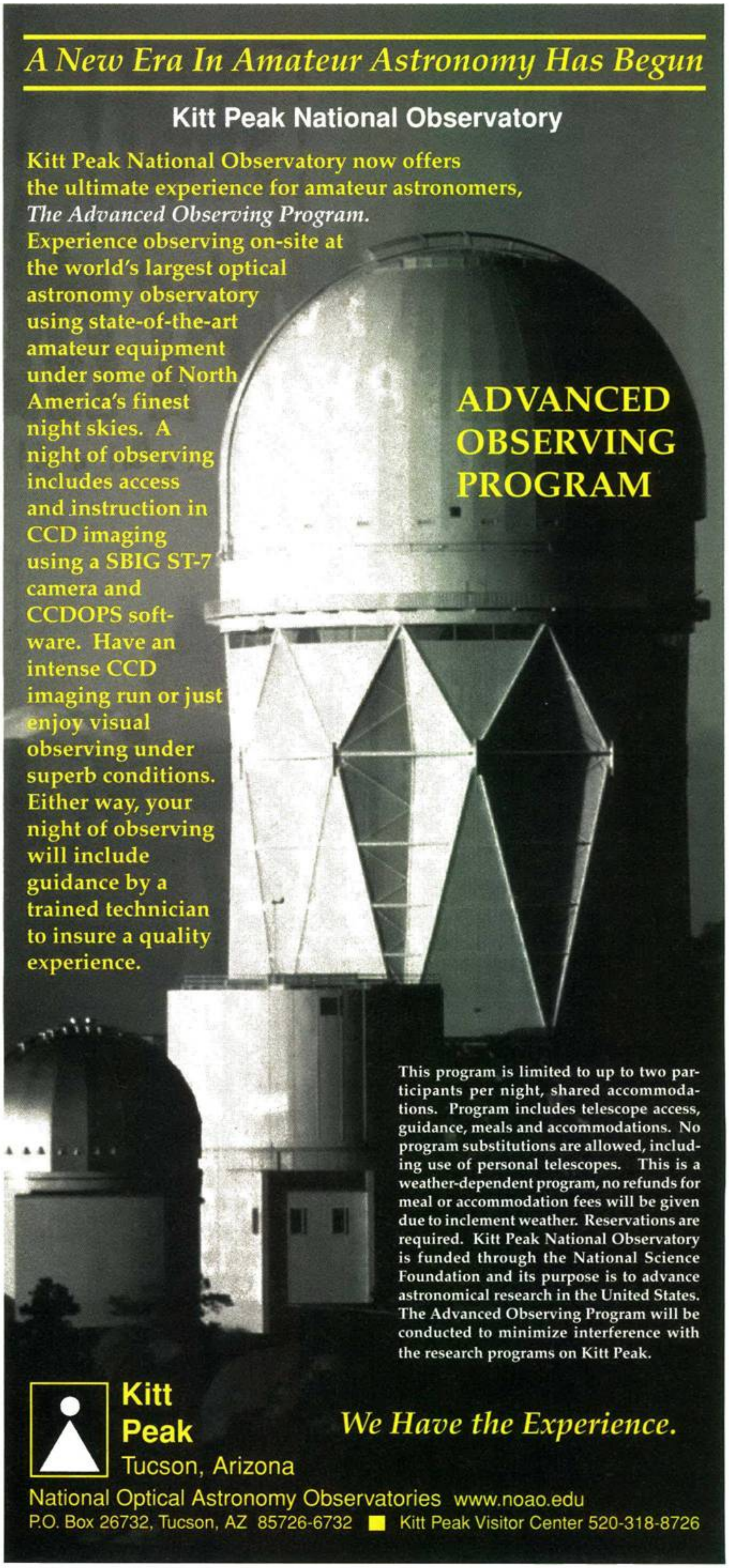
Your July 1997 issue caught my attention, first in the well-written caution from Rachel Lerner in your letters section. Lerner chided you for an uncharacteristically demeaning remark about the singer Madonna. I agree that it showed very poor taste.

Turning the pages, I found an interesting article about astronomer Heidi Hammel, written by Ruth Flanagan. But in the second paragraph I was floored by a description of Dr. Hammel which rivaled that made about Madonna. The author wrote, "She meticulously choreographed her observing program. She lined up every dress, every shoe, every hairband in her closet with military precision."

Unfortunately, this isn't the only time I've read such an absurd and irrelevant statement about a woman scientist, but from *Astronomy* I was surprised. Strike two. — *John D. Lyle, Fairbanks, Alaska*

Seaman Turned Astronomer

My interest in astronomy began just over a year ago while working as a third mate aboard a cruise ship on a round-the-world cruise. I'd always had an interest in celestial navigation and enjoyed getting "back to the basics" and navigating using a sextant on the long ocean passages. I knew little of the individual stars and constellations,



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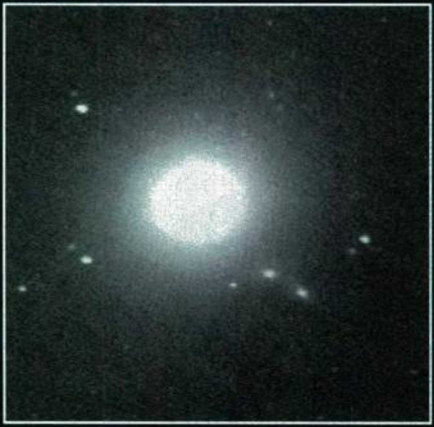

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however, until on one such passage I was approached by the captain to give a talk on the night sky to our passengers in the Red Sea.

At first the prospect daunted me, but as I began to read up on the subject, I became captivated and threw myself at the task with a passion. I learned all that I could about the constellations, their origins, and their history, and prepared to give my first star lecture. As an added bonus, Comet Hyakutake was also putting on a great show at that time, and I could include it in my research and my lecture itself.

On the night of the lecture I armed myself with a powerful portable search light for pointing out the individual stars, cued up the theme to *Star Wars* over the open decks, and headed outside to the darkness of the upper deck to be confronted with nearly a third of our 1,500 passengers crowded in front of me for my stargazing lecture.

The skies performed beautifully that evening and my hard work was rewarded with a wonderfully clear night and a great view of Hyakutake. And I was amazed and encouraged by the interest shown in the "wonders of the firmament," as the show was billed in the daily program.

Since that time, my interest has continued to grow and I can't wait to purchase my first telescope in the near future and begin to look further into those same wonders. — *Steve Pritchard, Kent, England*

Star Stuff Correction

The product announcement for Nisur System's P3 TriPier altazimuth mount for small telescopes in the September issue, p. 90, contained two incorrect phone numbers. The correct area code for both the information line and fax number is 201, not 210. The toll-free number for Napier Enterprises should have read (800) 567-2434.

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ASTRONEWS

GALILEO MISSION

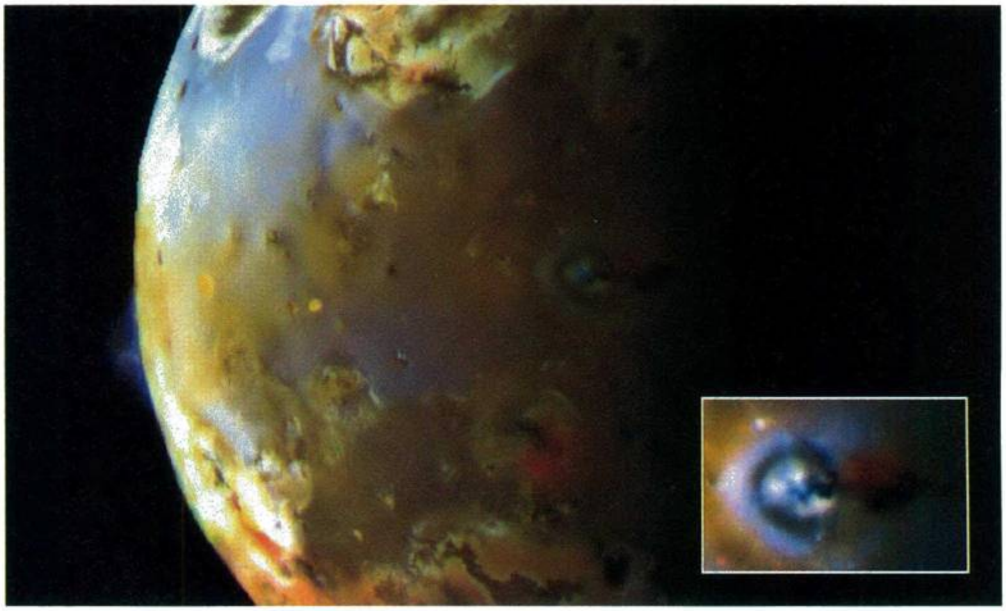
A Hot Time on Io

▶As the most volcanically active object in the solar system, Jupiter's moon Io is constantly wracked by titanic eruptions and scorched by searing lava. The Galileo spacecraft captured the most recent of these pyrotechnic displays when it made its eighth and ninth trips through the jovian system.

During orbit number eight in early May, Galileo turned its camera toward Io as Jupiter was blocking the sun from view. In the resulting eclipse photo (right, below), the red and yellow spots mark areas where high-temperature magma has erupted onto the surface. The hottest of these glowing lava flows and lava lakes have temperatures of more than 1500 kelvins.

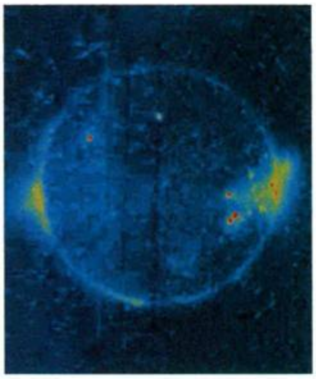
The field of hot spots on the right-hand side of the image lies nearly dead center on the hemisphere that always faces Jupiter. The extended, diffuse glow rising above the limb on the left lies over the active volcano Prometheus. When seen by reflected sunlight, this plume rises about 75 kilometers (45 miles) above the surface. In this view the glow stretches roughly 800 km (500 miles) high. The extended glow proves that gases or small particles climb to much greater heights than the heavier material in the dense inner plume.

The diffuse glow above the limb on the right side of the photo reaches a height of 400 km (250 miles). Surprisingly, no volcanic plume has been seen in reflected light in this region before.



On orbit number nine in late June, Galileo captured two erupting plumes in the same image (above). The plume on the bright limb rises 140 km (85 miles) above the volcanic caldera called Pillan Patera. In 1999, during Galileo's extended mission, the spacecraft will pass just 600 km (375 miles) above this volcano.

The second plume lies near the terminator (the boundary between day and night) and rises above the volcano Prometheus. In the inset, the reddish shadow of the plume can be seen extending to the right of the eruption vent (which itself lies near the center of the bright and dark rings). The Prometheus plume appears in every Galileo image and every Voyager image from 1979 having the right geometry, raising the possibility that this volcano has been erupting continuously for more than 18 years.



Galileo captured these complementary images of Io's volcanic activity in mid-1997. The spacecraft caught two plumes in reflected sunlight (above), as well as the shadow of the plume rising above Prometheus (inset). The photo of Io in eclipse (left) reveals hot spots caused by erupting magma as well as diffuse glows from volcanic plumes near the moon's limb. NASA/JPL

EARTH BOMBARDMENT

Support for Mini-Comet Theory

▶The debate continues to rage as to whether mini-comets the size of a house slam into Earth at a rate of 5 to 20 every minute. On one side is Louis Frank and his colleagues at the University of Iowa. On the other is much of the rest of the scientific community. But two new pieces of evidence lend some support to Frank's position that large numbers of water-rich mini-comets are indeed hitting Earth.

The CRISTA-SPAS satellite, built by Germany and launched and retrieved by the Space Shuttle Discovery this past August, measured considerably more hydroxyl (OH) in Earth's upper atmosphere than current models predict. And the parent molecule of hydroxyl is water (H_2O). Because ultraviolet radiation

(see "Mini-Comets," p. 26)

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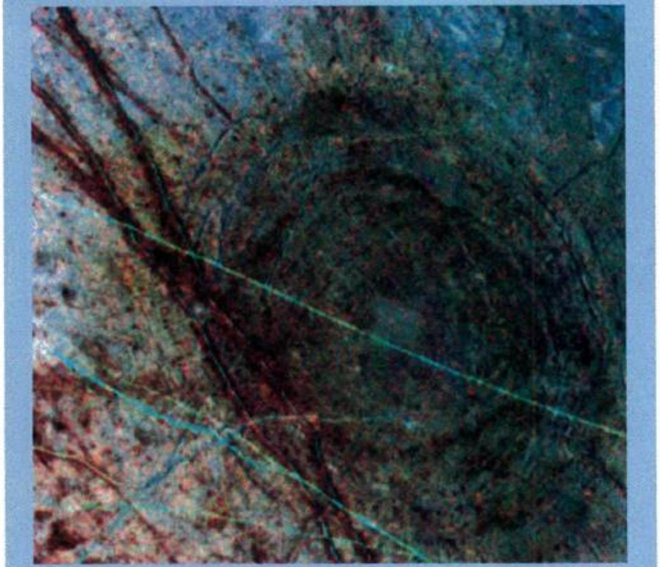
(Mini-Comets)

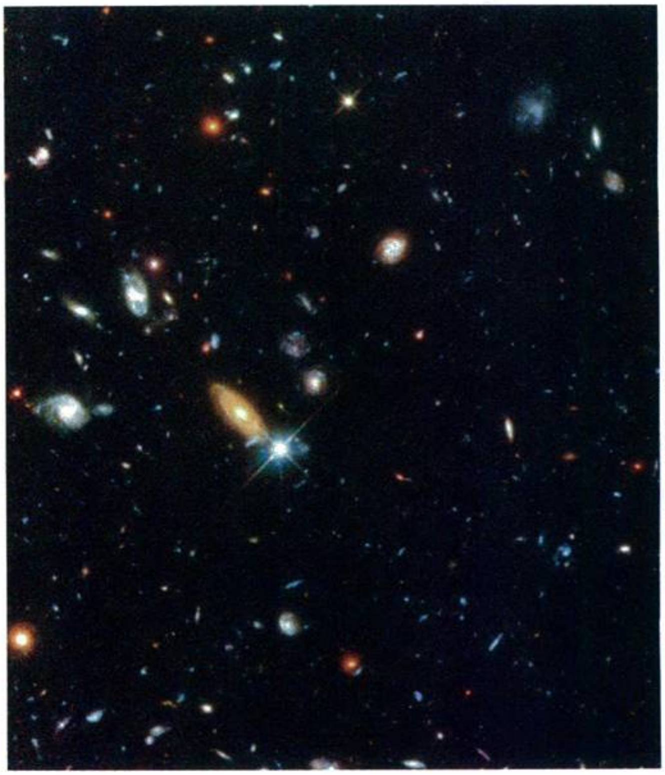
from the sun breaks down any water that exists in Earth's upper atmosphere into hydroxyl and hydrogen, a large amount of hydroxyl up there implies a large influx of water, just as Frank's mini-comet model predicts. In addition, a new analysis of data from NASA's Upper Atmosphere Research Satellite, launched in 1991, shows much more water vapor at high altitudes than originally thought.

"The question that remains open and needs to be investigated by the scientific community is where does this water come from?" says Robert Conway of the U. S. Naval Research Laboratory, the principal investigator of MAHRSI, the instrument on-board CRISTA-SPAS that detected the large quantities of hydroxyl. "We certainly haven't confirmed Frank's comet theory, but we absolutely have to recognize that these high values of water and hydroxyl require some explanation."

GALILEO



THE YOUTHFUL SURFACE OF EUROPA stands out in this false-color view of the impact scar Tyre. The bull's-eye pattern, measuring 140 kilometers (85 miles) across, formed when a mountain-sized asteroid or comet slammed into the satellite. After the impact, a mixture of dirty water ice oozed to the surface, creating the reddish lines superposed on Tyre. The fine blue-green lines running east to west appear to be ridges that formed after the crater. Most important, the entire region appears remarkably flat, suggesting that at the time of the Tyre impact, Europa's surface was just a thin sheet of ice lying on top of an ocean of water. NASA/JPL



Robert Williams and the Hubble Deep Field Team (STScI) and NASA

COSMIC ENIGMA

Mystery Objects in the Deep Field

▶The Hubble Deep Field (shown above), taken by the Hubble Space Telescope over a 10-day period in December 1995, has now revealed far more than the approximately 3,000 galaxies first identified in the image.

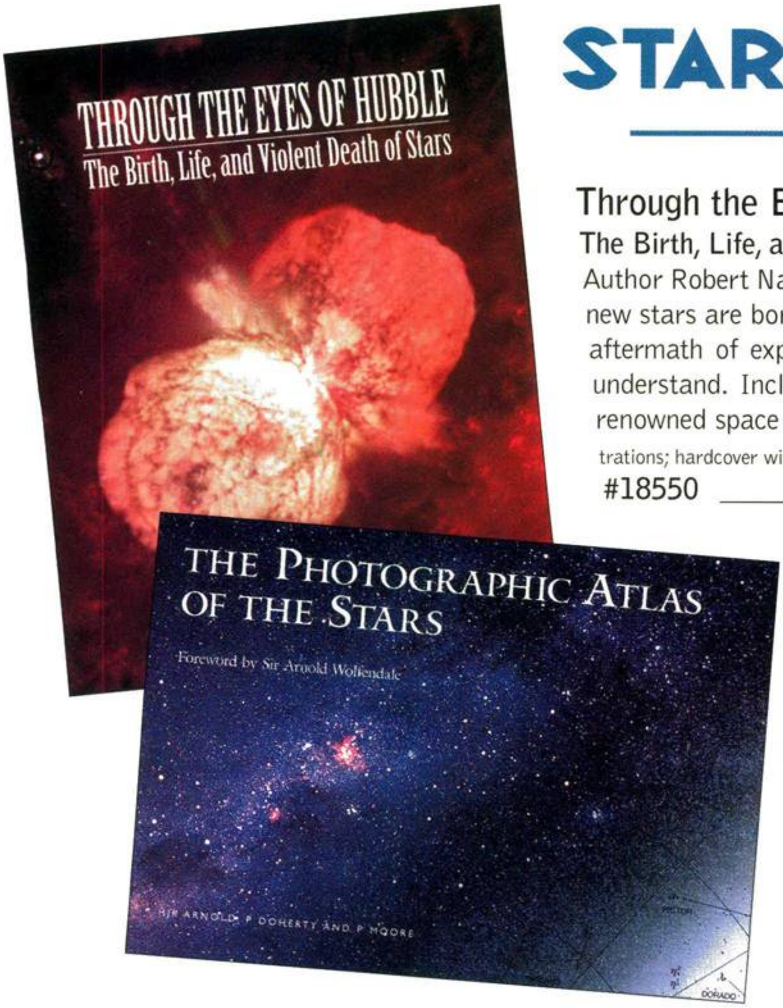
Scattered among these distant galaxies, which stretch nearly to the edge of the universe, are what appear to be about 90 very dim foreground stars in our own galaxy. When scientists decided to take a closer look at these objects, however, they discovered something quite unexpected.

"They aren't stars," says John Bahcall of the Institute for Advanced Study in Princeton, New Jersey. Stars appear as distinct points, with the light intensity falling quite suddenly as you move away from the center of the star's image. With these objects the light drops off much more slowly. "They have a fuzziness," says Bahcall. "We have found a population of objects that look stellar but aren't when you look real close."

These objects, first thought to be ordinary stars residing in the halo surrounding the Milky Way Galaxy, appear very faint and most have a bluish color. "Though we don't as yet know for sure," says Andy Gould of Iowa State University, "we suspect they are extragalactic."

While it's very possible they will turn out to be nothing more than extreme examples of ordinary objects that have already been cataloged, the astronomers are very much intrigued by them. "I am very interested in finding out what they are," Bahcall notes.

—Robert Zimmerman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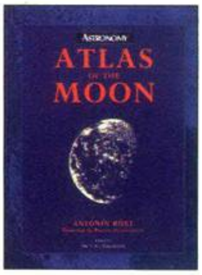
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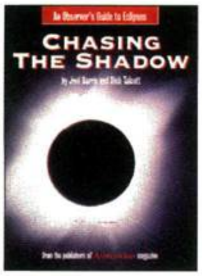
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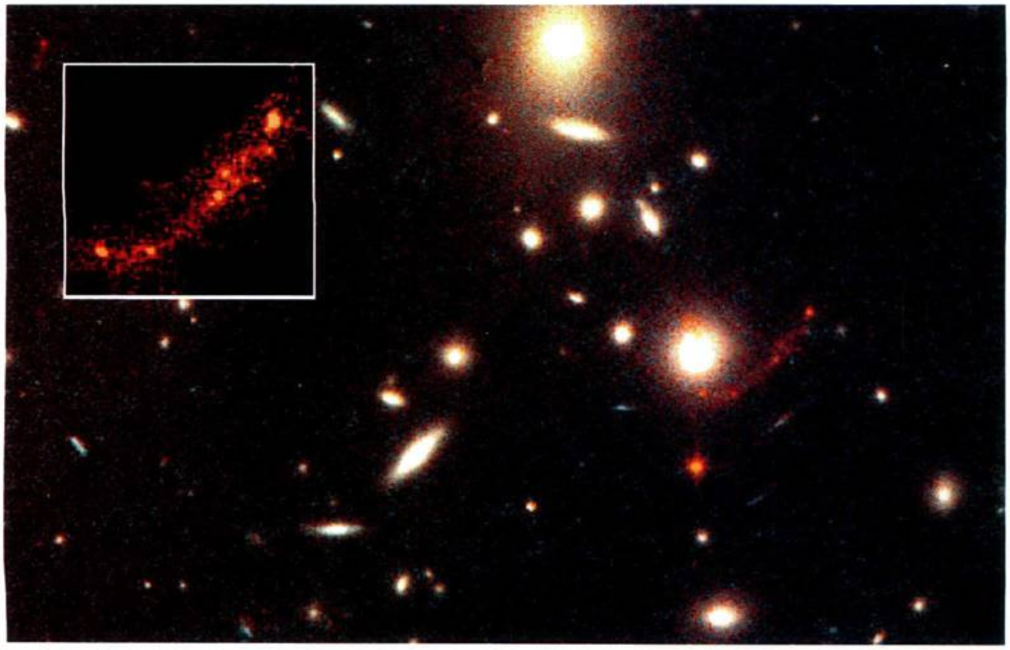
MOST DISTANT GALAXY

With a Little Help from Nature

A recent image from the Hubble Space Telescope has turned up a new record holder for the most distant known object in the universe. The red arc to the lower right of center in the image (below) is actually a young galaxy some 13 billion light-years away. We see it this clearly only because a foreground cluster of galaxies (the yellowish blobs at center, which are located about five billion light-years away) acts as a gravitational lens, amplifying and smearing the light of the more distant galaxy.

Spectra taken with one of the twin 10-meter Keck Telescopes in Hawaii confirmed the vast distance by showing that the galaxy has a redshift of 4.92 (the previous record holder, quasar PC1247+34, has a redshift of 4.90). The galaxy's bright splotches (seen best in the inset) represent pockets of intense star formation about 700 light-years across. "Based on this image we can begin to make some conclusions about the early growth of galaxies," says Garth Illingworth of the University of California at Santa Cruz. "The knots show that starbirth happens in very tiny regions compared with the size of the final galaxy."



Marijn Franx (Univ. of Groningen), Garth Illingworth (Univ. of California at Santa Cruz), and NASA

CHANGING DYNAMICS

Hoppin' the Solar System

Can solar system objects suddenly jump from one orbit to another? Observations clearly show that the answer is yes. For example, in the late 1930s Comet Oterma jumped from an 18-year orbit around the sun into an 8-year orbit. Then in the early 1960s, the comet jumped back to an 18-year orbit. At least nine other comets have performed at least one such jump.

In the April 1997 *Astronomical Journal*, University of Minnesota mathematician Edward Belbruno and Harvard astronomer Brian Marsden provide an explanation they call "the hop." Between the two hops, Comet Oterma was in a so-called 3:2 resonance with Jupiter, meaning it completed three orbits of the sun in the same length of time it took Jupiter to go around twice. But before the first hop and after the second, the comet was in a 2:3 resonance with Jupiter, completing two solar circuits for every three made by Jupiter.

According to Belbruno and Marsden, Comet Oterma "hopped" from one resonance to the other. The trigger occurred when it ventured into a critical region of the solar system where it felt equal gravitational tugs from Jupiter and the sun. At this point in space, the comet didn't know exactly which body it was supposed to orbit.

In both hops, the comet apparently wandered around chaotically for approximately two years before settling into a new orbit. "Most changes in astronomy occur very slowly, but the hop happens with lightning speed, which makes the solar system a more dynamic place," says Belbruno.

The hop mechanism has important ramifications for space travel and the solar system. Belbruno and Marsden show that the hop provides a way for comets to suddenly jump into Earth-crossing orbits, meaning comets may have smashed into Earth more frequently than previously estimated.

The hop also works for the Earth-moon system; Belbruno has already demonstrated a mechanism to allow spacecraft to travel to the moon using much less fuel than did the Apollo missions. Recent calculations by Belbruno indicate that Kuiper Belt objects — many of which (including Pluto) share a 3:2 resonance with Neptune — hopped into their present eccentric orbits after close approaches to Neptune. "A resonance is a smoking gun — a sign that the hop may have occurred," says Belbruno.

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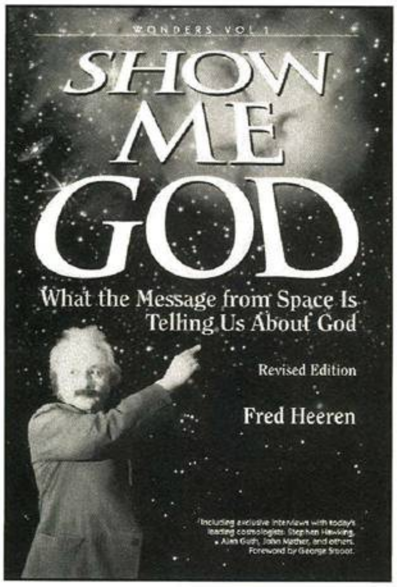
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SPECIAL REPORT

Mars Pathfinder Update

▶Talk about exceeding expectations! Six weeks after landing on Mars, as this issue of *Astronomy* was going to press, the Pathfinder lander continued to perform superbly and the Sojourner rover was still chugging along. Both the rover and lander had already fulfilled their primary missions, so every image or bit of data returned since then has been gravy.

Mars Pathfinder has already upset several long-standing notions about Mars's geology and atmosphere. Several rocks sampled by Sojourner's alpha proton x-ray spectrometer, especially Barnacle Bill and to a lesser extent Yogi, are more Earth-like than scientists had expected. In particular, these two rocks have a much higher silica content than the 12 meteorites thought to have come from Mars. Rocks can only become rich in silica after being heated and differentiating. "This suggests that there was more crustal activity — heating and recycling of materials — early in Mars's history than we thought," says project scientist Matthew Golombek of JPL. In other words, the Red Planet has experienced volcanic reprocessing of rocks, much like Earth but unlike the moon.

The Imager for Mars Pathfinder (IMP) snapped this image of a martian sunset one minute after the sun sank beneath the western horizon. The Twin Peaks are clearly seen in silhouette. The martian sky stays bright up to two hours after sunset, probably from sunlight reflecting off high-altitude dust particles.

This is the first color image of martian clouds taken from the surface. The pink stratus clouds consist of water ice that has condensed on red iron-oxide dust particles suspended in the atmosphere. The clouds are about 10 miles high and move at a speed of 15 miles per hour (24 km per hour).

Despite their surprising similarity to terrestrial rocks in silicate content, Barnacle Bill, Yogi, and the soil exhibit other chemical signatures (particularly the ratio of iron to manganese) that closely match the 12 martian meteorites. This indicates that these meteorites, including the possible microfossil-bearing rock ALH84001, did in fact come from Mars.

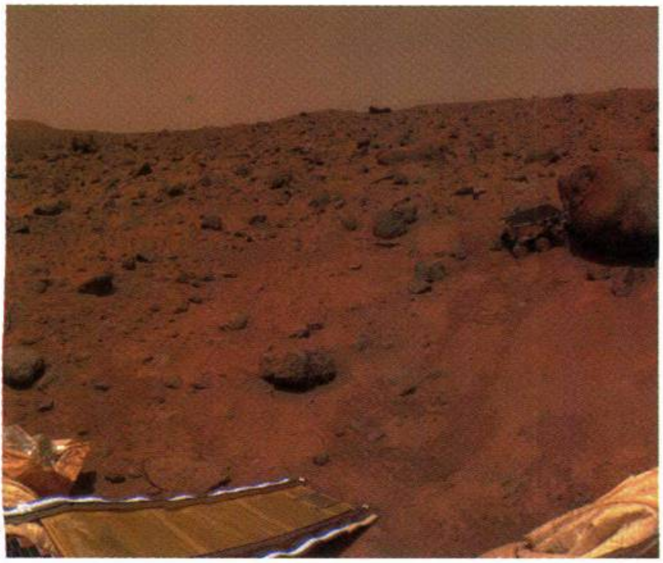
Perhaps the biggest surprises have come from the lander's weather instruments, which unlike those on the Viking landers can sample the atmosphere every few seconds. Temperatures can plummet 10° to 15° F (6° to 8° C) just a few feet above the surface, and temperatures at ground level can fluctuate an amazing 40° F (22° C) within a few minutes. Such extreme variations indicate that Mars's thin atmosphere can be extremely turbulent, with small eddies and convection cells rising off the warmer surface in the morning.

Although winds at the site have generally remained light, instruments recorded a dust devil that passed right over the lander on its 25th day on Mars. Calm winds have not always prevailed, however — images from the lander and rover clearly show that powerful gusts over the eons have eroded and sculpted nearby rocks.

Sojourner's analysis of the martian soil shows that it's very similar to the soil at the Viking 1 and 2 sites, both of which are more than 600 miles (1,000 km) away. This suggests that Mars's soil is nearly the same everywhere, probably the result of mixing by winds.

As of August 3, the end of the 30-day nominal mission, Pathfinder had returned 9,669 images and 1.2 billion bits of data to eager scientists on Earth. Scientists are just beginning to sift through this mountain of information, and the rover's spectrometer has continued to examine more rocks.

— ROBERT NAEYE



Sojourner's alpha proton x-ray spectrometer is "sniffing" the rock affectionately known as Yogi. The spectrometer revealed that Yogi could be a basalt, a common volcanic rock on Earth and all the other inner planets. Yogi and other martian rocks appear to have chemical similarities to terrestrial lavas, indicating that Mars was geologically active in the past.

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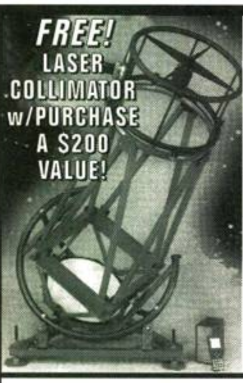

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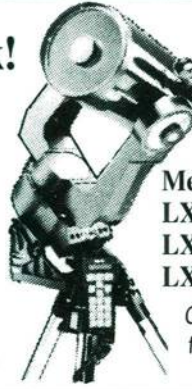

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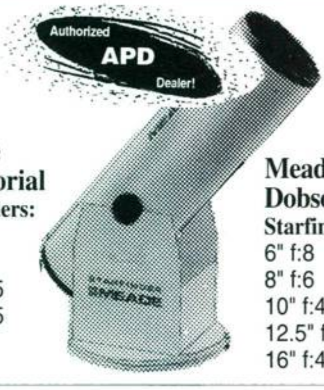

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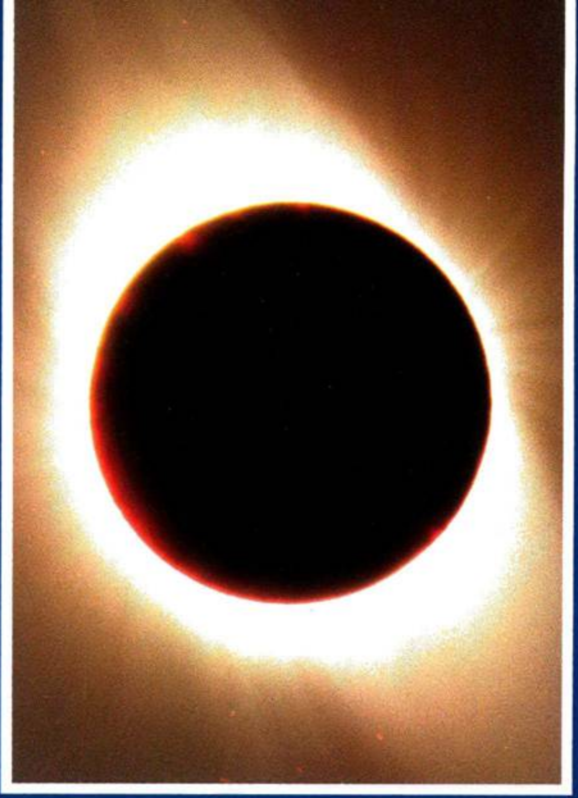

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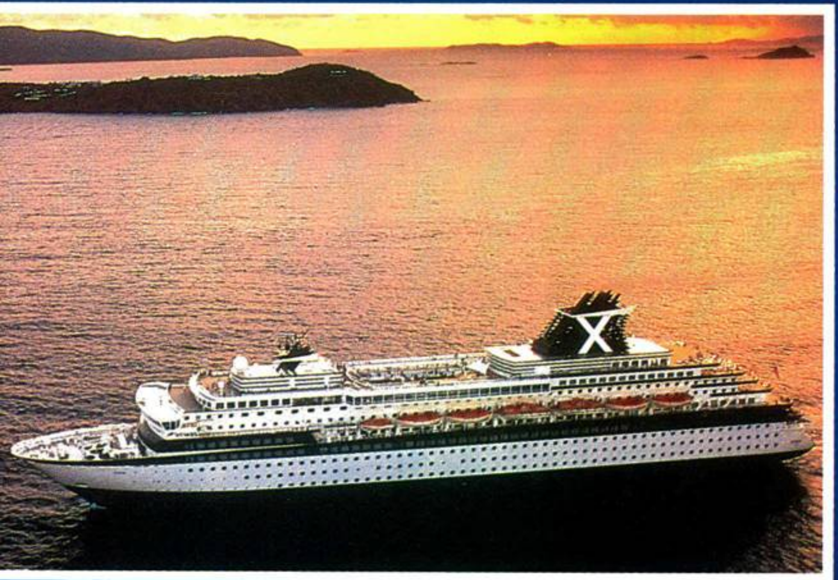

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Bound for THE RI

The Cassini spacecraft will help resolve many long-standing mysteries surrounding Saturn, its rings, and its moons.

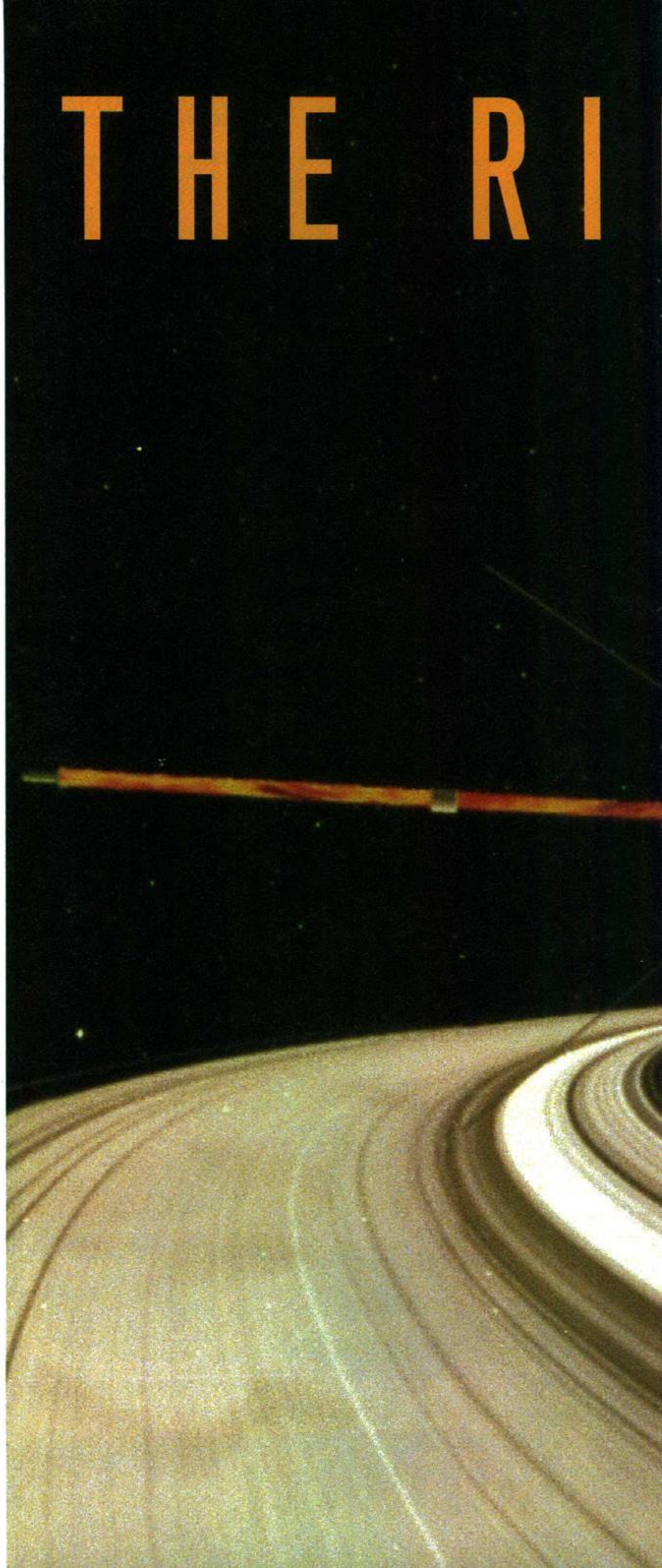
by Josh Rogan

"To be in this business, you can't be an impatient person," says University of Arizona astronomer Carolyn Porco, and she knows what she's talking about. For seven years, Porco has worked to help plan the Cassini mission to Saturn, a joint effort of NASA and the European Space Agency. After Cassini's launch on a Titan IV booster this month, she and her colleagues will have to endure seven years of waiting before the six-ton spacecraft arrives at its destination in July 2004. Scientists have high hopes for Cassini; its mission could answer some lingering fundamental questions about the majestic Ringed Planet.

THE PLANET

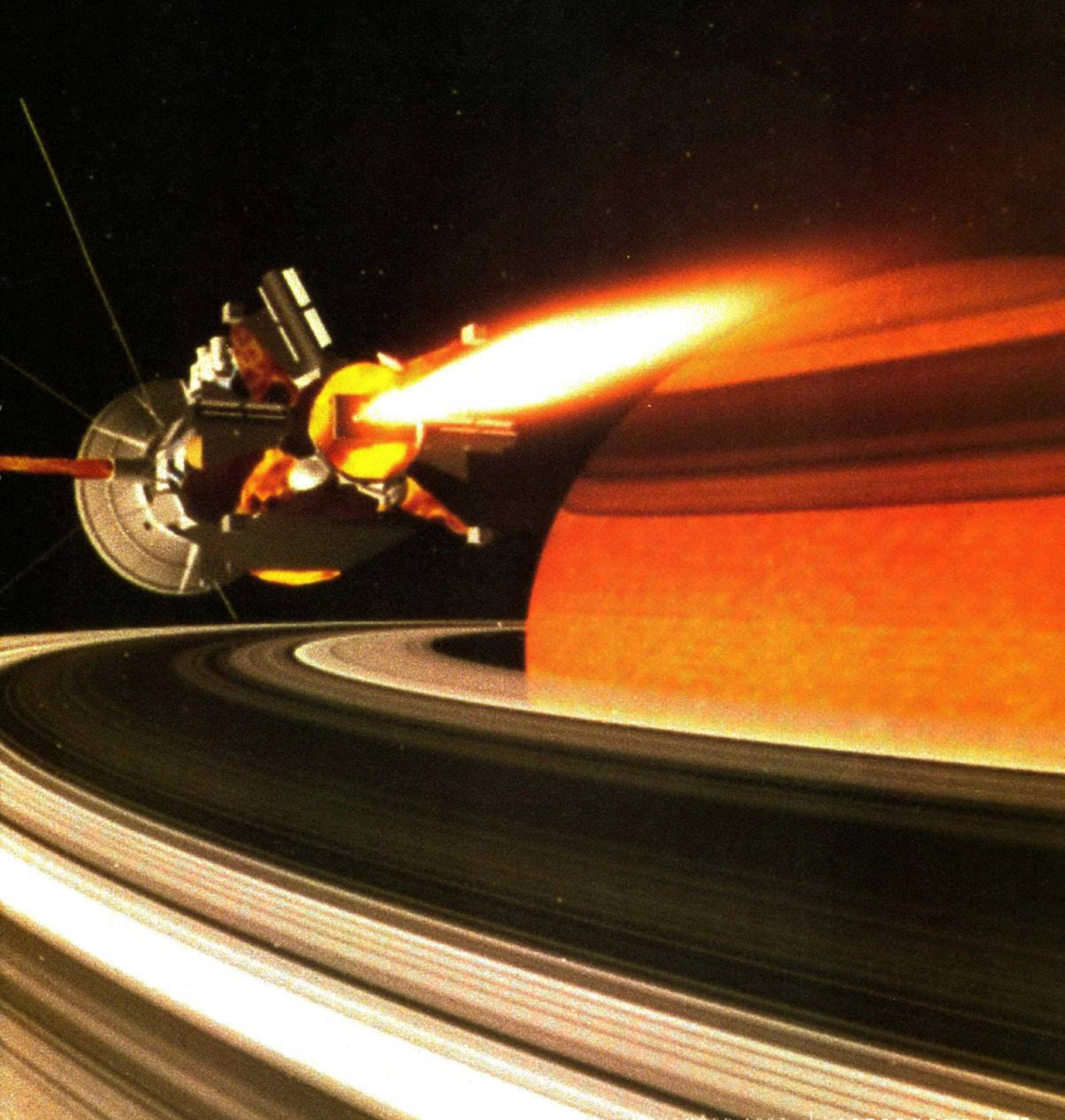
Runner-up among the planets in size (second only to Jupiter), Saturn was last visited by the twin Voyager probes, which made flybys in 1980 and 1981. But these missions raised as many questions as they answered. As Cassini scientist Michael Flasar of NASA's Goddard Space Flight Center explains, "The problem with Voyager is that it just flew by, and it was a real quick look." As a result, Flasar says, scientists have never had the chance to give Saturn a truly in-depth examination.

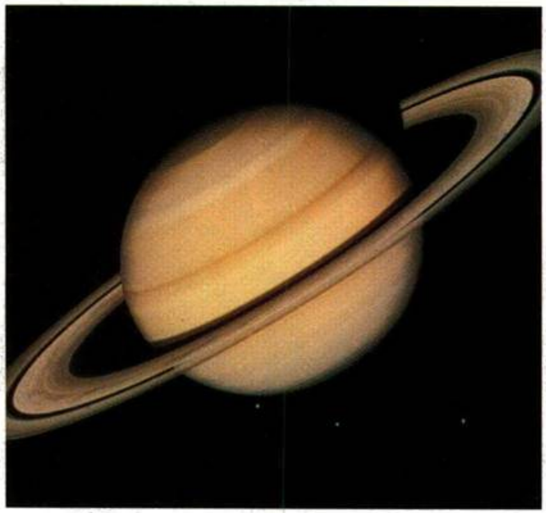
Scientists are counting on Cassini to remedy the situation. After going into orbit around Saturn, Cassini will begin a four-year tour of the planet, its rings, and its moons. For many scientists, Saturn's largest satellite Titan will be the star of the show; Cassini will deliver an instrumented probe called Huygens to descend into Titan's murky atmosphere, and the orbiter itself will map the surface of the cloud-



If all goes according to plan, Cassini will fire its thrusters on July 1, 2004, in order to slow down enough to orbit Saturn. Illustration: NASA-JPL/David Seal

NGED PLANET




NASA-JPL

Voyagers 1 and 2 returned spectacular images and data, greatly adding to our understanding of the saturnian system. But the Voyager flybys lasted only a few hours. Cassini, with its more sophisticated instruments, will go into Saturn orbit, where it will return years of data.

enshrouded world using radar. But Cassini will also stage a thorough investigation of Saturn itself.

Among the mysteries that Cassini might resolve: What creates the so-called zonal jets, horizontal bands that cross Saturn's cloudy upper atmosphere? Voyager showed that Saturn's zones, like Jupiter's, are associated with rapid winds. In fact, Saturn's winds are even more energetic than Jupiter's, reaching speeds as high as 1,100 miles per hour. But what drives these winds? To answer this question, Cassini is outfitted with a powerful array of instruments, including a high-resolution camera that will be used to document the motion of Saturn's clouds.

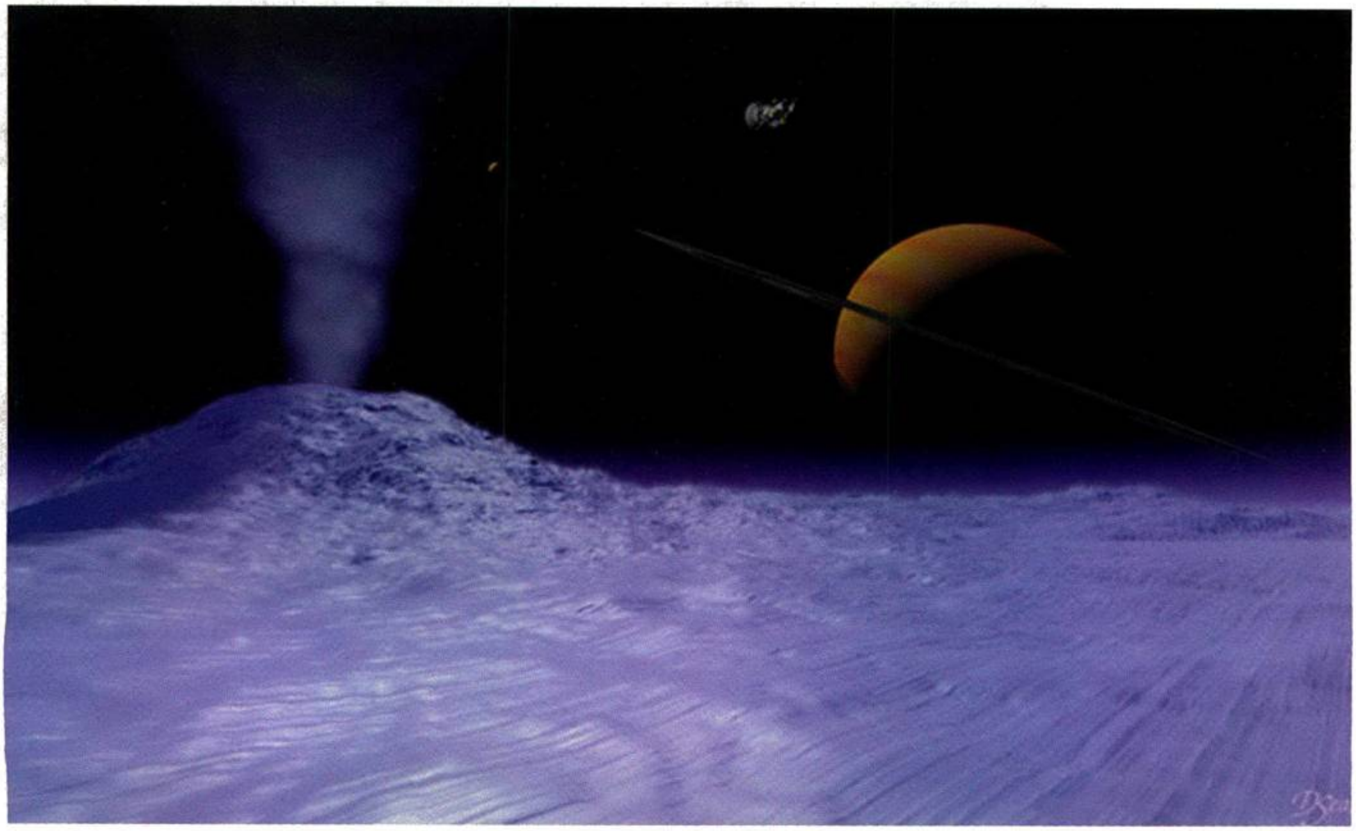
Observing Saturn's atmosphere, however, poses some challenges. Unlike Jupiter, Saturn's clouds are veiled by high-altitude hazes. And in Voyager images, the saturnian atmosphere is relatively bland, making individual features difficult to recognize. But Cassini will have a distinct advantage. Its images will have higher resolution and will sample a much wider range of the spectrum, from ultraviolet to infrared.

As with Jupiter, Voyager saw storms on the margins of Saturn's zonal jets. These storms might help sustain the jets by supplying them with energy, as recent analysis by Caltech's Andrew Ingersoll and New Mexico State's Reta Beebe suggests. Alternatively, they may work to restrain the jets' speeds by siphoning energy away from them. Cassini scientists hope to resolve the uncertainty by tracking the movements of individual storms.

Scientists are also anxious to investigate Saturn's atmosphere in the vertical dimension. Cassini will not release a probe into Saturn's atmosphere, as Galileo did at Jupiter, but it will use other methods. One of these takes advantage of the fact that Cassini's radio signals to Earth will pass through Saturn's atmosphere each time the orbiting craft disappears behind the planet and then reappears. These so-called radio occultations will repeat an experiment that was made in a limited way during the Voyager flybys. By analyzing variations in the radio signals, scientists

Cassini will find out if ice geysers on Saturn's moon Enceladus supply the outer E-ring with material.

Illustration: NASA-JPL/David Seal



will obtain data on temperatures, pressures, and compositions within Saturn's upper atmosphere. Unlike the Voyagers, which performed only two radio occultations of Saturn per flyby, Cassini will perform dozens, sampling the atmospheric structure in many places and at many different times.

More information on the atmosphere's vertical structure should come from Cassini's images. "The hope is that when you're looking at different wavelengths, you're sampling different altitudes in the atmosphere," says astronomer Anthony del Genio of NASA's Goddard Institute for Space Studies. If so, then scientists may be able to measure wind speeds in deeper layers. Cassini's imaging system will search for flashes of lightning over Saturn's night side — something that would indicate the presence of deep water clouds. "We're not counting on that," says del Genio, but if they are successful, "we get a real bonus."

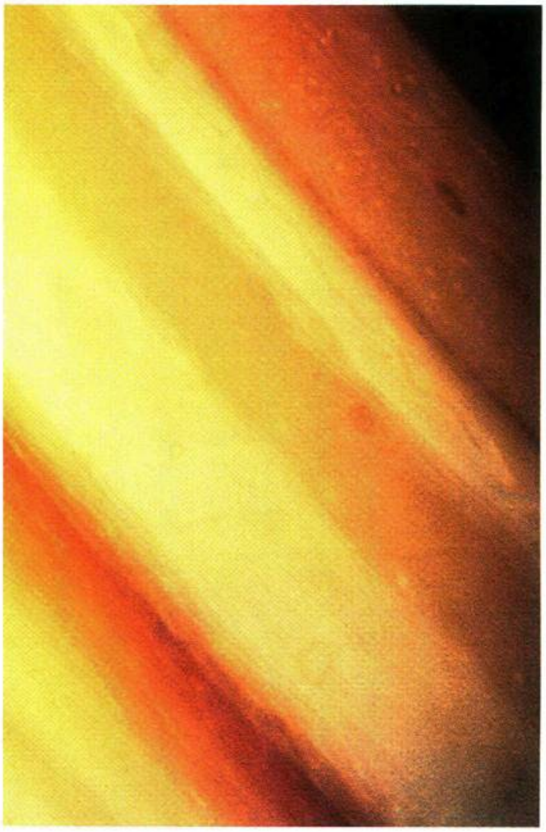
Many planetary scientists believe heat from the interior is a major influence on Saturn's atmospheric circulation. The planet radiates about 80 percent more heat than it receives from the sun, a fact no one has yet explained. Most of Saturn's gaseous bulk is composed of a mixture of hydrogen and helium, and scientists have speculated that over the planet's 4.6-billion-year lifetime, heavier helium atoms have migrated toward the planet's core, producing heat as they do so. Voyager seemed to confirm this by discovering that Saturn's outer atmosphere is depleted in helium. If Cassini is able to confirm this finding, it will not only explain Saturn's excess heat, but it will also help scientists better understand the evolution of the gas-giant planets.

THE RINGS

Saturn's rings are the planet's most striking feature, and to scientists, the most puzzling. The Voyagers revealed that the rings possess far more structure than anyone expected, including a host of bizarre features — clumps, kinks, spokes, and braids, which even now challenge scientists' understanding. Says Carolyn Porco, "We can't explain 90 percent of the features we see in the rings." For that reason, Porco and her colleagues are looking forward to seeing how the rings have changed since Voyager and to finding out how fast the rings evolve during Cassini's four-year tour.

Cassini will also provide the best chance yet to investigate the rings' compositions. Voyager revealed that there are subtle variations in composition from one part of the rings to another. But Cassini's sensors, with their greater range of spectral response, will allow far more detailed analyses. Probing the rings at far-infrared and microwave wavelengths, Cassini's instruments should even be able to detect any rocky material that may lie beneath the ring particles' icy surfaces.

Of course, one of the biggest hopes for Cassini is that it will help determine where the rings came from. Most scientists agree that the rings did not form at the time Saturn and its satellites formed. Current estimates place the rings' age at 100 million to 200 million years, suggesting that they formed when a pre-existing body strayed too close to Saturn and was torn apart by tidal forces. But was the rings' parent world one of Saturn's moons, or was it an interloper from another region of the solar system? Comparing Cassini's data on the rings' compositions with those of Saturn's satellites, along with ground-based data on other known solar system objects, should help clear up the uncertainty.



Cassini will investigate the banded structure of Saturn's upper atmosphere, where wind speeds top 1,000 miles per hour. The six-ton spacecraft is named after the astronomer Giovanni Cassini (1625-1712), who discovered the apparent gap in Saturn's rings known as the Cassini division.

NASA-JPL

Observing the rings may shed light on the formation of the planets. More than 4.6 billion years ago, grains of ice and dust within the primordial solar nebula would have resembled Saturn's ring particles as they are now. Watching the ring particles interact as they circle Saturn should tell planetary scientists much about how dust and ice particles aggregated into larger bodies during the early stages of the solar system's formation.

This in turn will shed light on the rings of the other gas-giant planets. Jupiter, Uranus, and Neptune all possess ring systems, each of which has an analog circling Saturn. "By going to Saturn's rings, you really study all the ring systems," says Jeff Cuzzi of NASA's Ames Research Center.

THE MOONS

Of Saturn's 18 known satellites, Titan will receive the most attention from Cassini. But other satellites hold great fascination for scientists, and Cassini will improve on Voyager's tantalizing views. In addition to 40 planned flybys of Titan, Cassini will have approximately six flybys of

Saturn's medium-sized icy satellites at altitudes between 300 and 1,200 miles (500 and 2,000 km). These encounters should produce remarkably detailed images. For example, Cassini should be able to map nearly the entire surface of both Iapetus and Enceladus at resolutions of 0.6 to 3 miles (1 to 5 km), comparable to the best Voyager images. And Cassini's best views of these satellites will be 100 to 1,000 times better, showing features as small as *ten feet* (3 meters) across. There will also be many satellite observations from much greater ranges.

Among Cassini's targets, none is more mysterious than Iapetus. Half of the moon's surface is covered with bright ice; the other half is as dark as asphalt and is thought to contain complex organic compounds. Cassini's images should help determine whether the dark substance comes from Iapetus's interior or from an outside source.

Cassini will also scrutinize another intriguing moon, Enceladus. Voyager images showed signs of volcanic activity — or cryo-volcanism, to be more exact. The surface of Enceladus contains far fewer impact craters than Saturn's other icy satellites; some areas appear to be completely devoid of craters. Geologists think that Enceladus has been resurfaced by outpourings of water from the icy moon's interior. The lack of craters suggests that this activity has occurred in the recent past. Cassini will try to determine whether active ice volcanoes now exist on Enceladus. If so, they may be spewing icy particles into space which then become part of Saturn's thin E-ring, which lies far outside the main ring system.

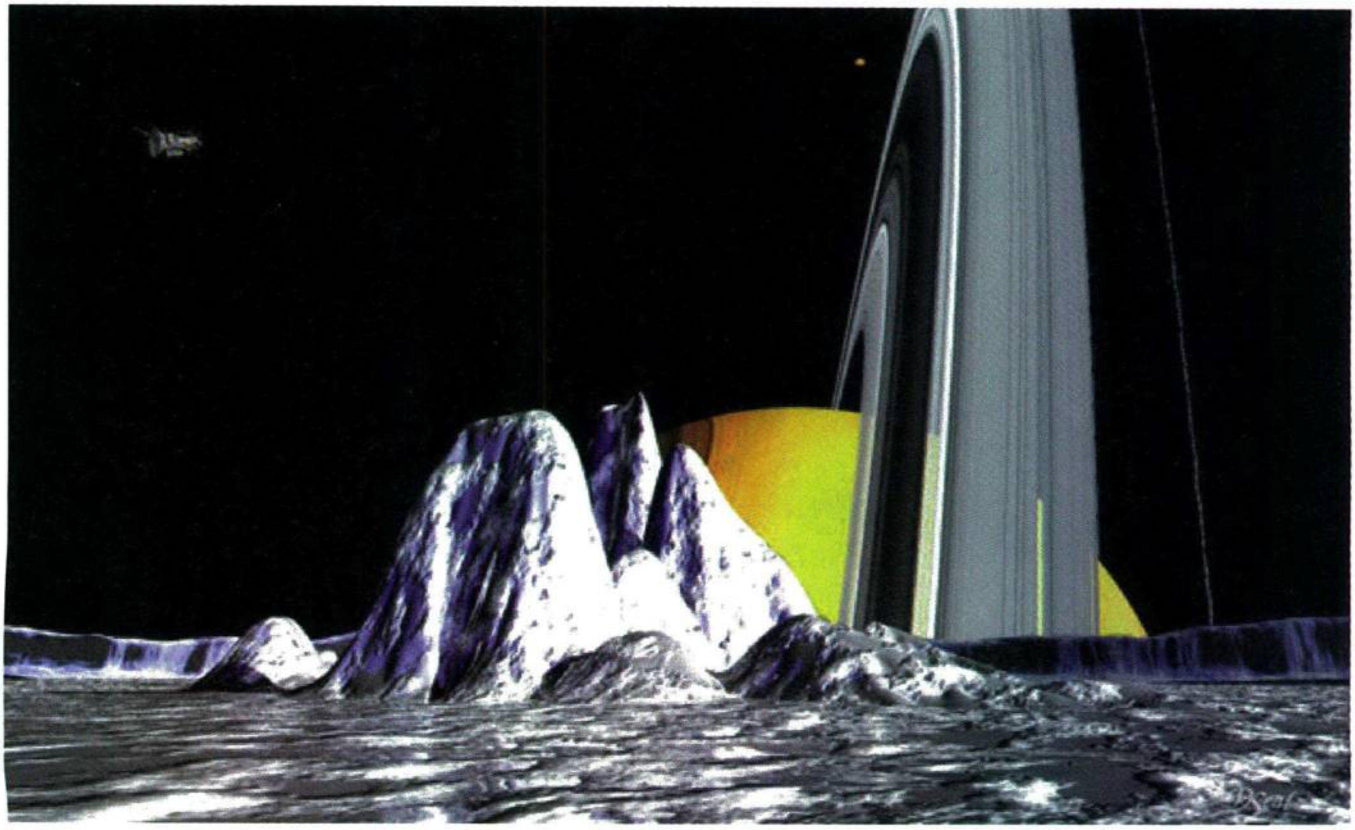
Within the rings themselves, Cassini will search for tiny moons previously seen by Voyager, such as the so-called shepherd satellites that constrain Saturn's narrow, braided F-ring. The spacecraft will also be on the lookout for previously unknown small satellites that are helping to maintain the structure of some of the rings.

THE MAGNETOSPHERE

Cassini will be a bonanza for scientists interested in Saturn's powerful magnetic field, whose total magnetic energy is some 540 times stronger than Earth's (Jupiter's magnetic field is 36 times stronger than Saturn's). Scientists are eager to learn more about the structure of Saturn's magnetic field and to study its interaction with the rings, moons, and the stream of charged particles emanating from the sun, known as the solar wind.

Picking up where Voyager left off, Cassini will employ several instruments to study the magnetosphere, including a magnetometer and a plasma spectrometer to study highly ionized gas within the magnetosphere. Cassini will be the first interplanetary spacecraft to actually produce low-resolution pictures of charged-particle interactions within Saturn's magnetic field. Scientists are eager to know more about how these particles are distributed within the magnetosphere, and how they affect the rings and moons. For example, Cassini will try to find out whether the celebrated spokes in Saturn's B-ring are produced by such interactions, as some researchers have suggested.

Scientists hope Cassini's observations will shed light on another saturnian mystery, the source of

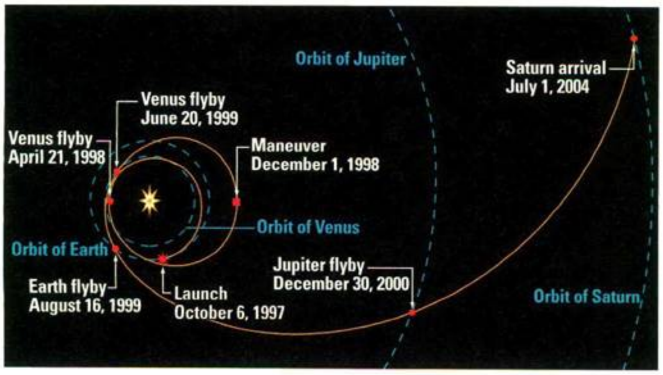


Central mountains tower above the floor of Herschel crater, which gives Saturn's inner moon Mimas the appearance of the Death Star in the Star Wars movies.

Illustration: NASA-JPL/ David Seal

The Cassini Spacecraft

Flagship of NASA's solar system exploration fleet, Cassini is the largest, most massive, and most technologically sophisticated interplanetary spacecraft the United States has ever launched. Cassini is more than 22 feet (6.7 meters) long and weighs some six tons. (Only the two Phobos spacecraft sent to Mars by the former Soviet Union were heavier.) Cassini is very much an international effort. Many components of the orbiter and most of the 770-pound (350 kg) Huygens probe were built by the European Space Agency. Cassini's scientific teams include 122 European researchers.



Cassini's journey to Saturn will be a circuitous one, including two flybys of Venus (scheduled for April 1998 and June 1999), one of Earth (August 1999), and one of Jupiter (December 2000). The planets' gravitational pulls will act as slingshots to accelerate the spacecraft toward Saturn. After firing its braking engine to go into orbit around Saturn in July 2004, Cassini will employ a dozen instruments in its scientific reconnaissance. Then, in November 2004, the Huygens probe will be dispatched for its entry into the atmosphere of Titan. The spacecraft will orbit Saturn 32 times during its nominal four-year science mission.

From the program's formal approval in 1990 until the end of the tour in 2008, the Cassini program will cost about $3.2 billion. NASA administrator Daniel Goldin has likened the spacecraft to Battlestar Galactica, and emphasizes that we may never again see such a complex, expensive, and capable planetary mission. "This is unfortunate, because a spacecraft like Cassini can study time variations and the interactions between diverse phenomena in a manner completely impossible for smaller spacecraft," says Cassini Science Manager Ellis Miner of the Jet Propulsion Laboratory.

Illustration by NASA-JPL/*Astronomy:* Terri Metzger

the planet's intermittent radio outbursts. Similar outbursts in other gas-giant planets have been associated with magnetic fields whose axes are offset from the rotational axes. But this explanation does not apply in Saturn's case: The magnetic axis coincides almost precisely with the axis of rotation, they are within one degree of each other.

THE JOURNEY BEGINS

For now, the Cassini teams are awaiting the spacecraft's departure with a mixture of anticipation and anxiety, hoping that the Titan IV booster safely delivers the spacecraft on its long and circuitous path toward Saturn. "The biggest hurdle is the launch," says Carolyn Porco. "After that I'm confident everything will go fine."

In recent months, the Cassini launch has been a source of controversy, as activists have protested NASA's use of a plutonium isotope in Cassini's power supply. An explosion during launch, or an accidental reentry during Cassini's close approach to Earth in 1999, the protesters say, would release highly toxic plutonium into the atmosphere.

NASA has refuted such claims. Even if controllers are forced to destroy the Titan booster during launch, say NASA spokespersons, there will not be any release of plutonium. Only the impact of the intact Titan booster and its Centaur second stage, a type of accident that NASA says is extremely unlikely, might result in some plutonium release. As for the idea that Cassini's Earth flyby might result in a reentry that would release plutonium, NASA says there is less than a one-in-a-million chance of that happening. Such explanations haven't appeased some protesters, who threatened to disrupt pre-launch preparations.

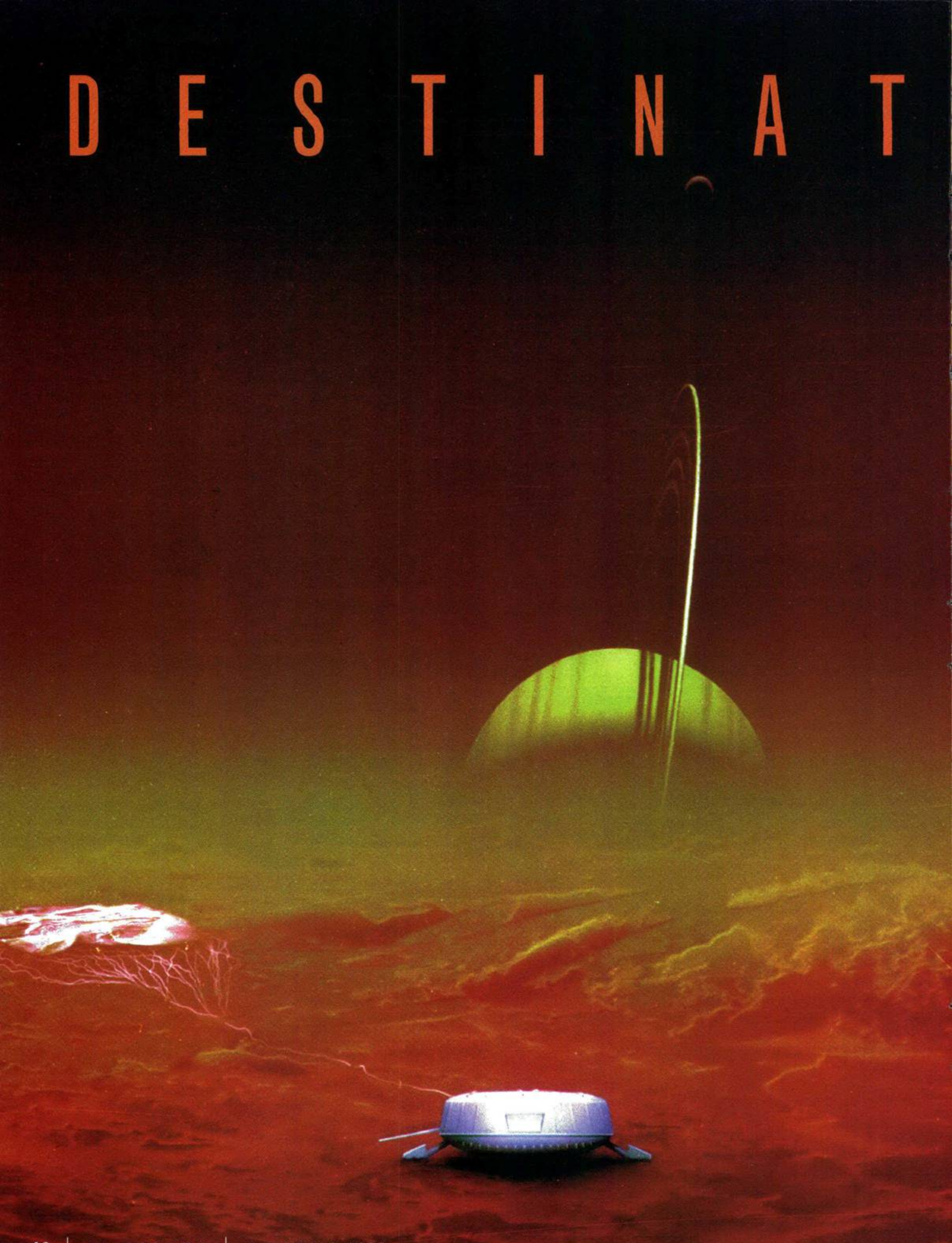
Of course, the launch will only begin the long wait before Cassini's data comes pouring in. For the scientists who have nurtured Cassini for the last seven years, it has been a real commitment. "I don't have kids," says Porco, "but I imagine it's like raising children." She adds with a laugh, "And right now, I'm just planning for college!"

For most Cassini scientists, the mission represents a once-in-a-lifetime opportunity to solve Saturn's mysteries, as Anthony del Genio explains. "Given the fact that I'm 46 years old, that I'm going to be 57 by the time we finish taking data, and that there are no other Saturn missions on the books at this time, this may be my last opportunity to try to answer those questions or to constrain theories on those questions with observations. We'd like to make sure we get the job done this time and not miss the opportunity."

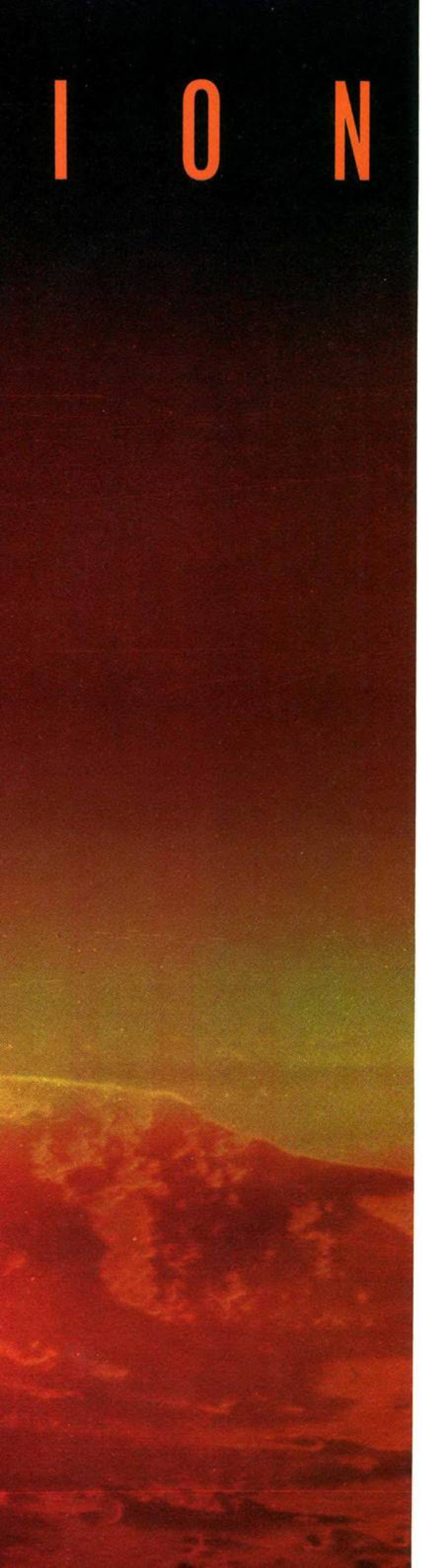
Science writer Josh Rogan has had a lifelong interest in astronomy and space exploration.

To learn more about Cassini and Huygens and to view the beautiful artistic renderings shown in this article and many more, check out NASA's Cassini website: http://www.jpl.nasa.gov/cassini/.

DESTINAT



ION TITAN



Saturn's moon may serve up an "ice cream" landscape and the keys to life.

by Steve Mirsky

In 1655, Dutch scientist Christiaan Huygens developed new techniques for grinding and polishing lenses. With the better optical instruments he could then produce, Huygens became the first human being ever to gaze upon Saturn's moon Titan. Shortly after Huygens's discovery, Italian astronomer Giovanni Domenico Cassini discovered four more saturnian moons, along with the gap in the planet's rings, known since as the Cassini division.

This October, a Titan IV rocket will hurl a spacecraft named Cassini on a two-billion-mile voyage through the solar system. As Cassini saw further by standing on the shoulders of Huygens, the spacecraft named for Cassini, in fitting tribute, will carry on its back a probe named for Huygens. The Dutchman would no doubt be delighted to learn that the Huygens probe will actually touch the moon he first glimpsed three and a half centuries ago.

He would also be surprised by how much, and yet how little, we still know about his discovery. "Titan is a remarkably mysterious place to us at this point," says Tobias Owen, an interdisciplinary scientist on Cassini and professor of astronomy at the University of Hawaii. "We can imagine things, but what we actually find will probably be different from what we imagine." Our imagination is fueled by observations done here on Earth and from flybys by the two Voyager missions in 1980 and 1981. Titan is shrouded in haze, so much so that the previous visitors there were not able to see the surface with their instrumentation. We do know that the thick atmosphere is mostly nitrogen like Earth's. The mere fact that there is a considerable atmosphere is noteworthy — it's the only one we know of on a moon. Methane contributes at least a few percent to Titan's vaporous blanket and there are more than a dozen other gases present in small amounts, including other hydrocarbons, which, like methane, consist of carbon and hydrogen. This combination of materials has an intriguing track record. On Earth, for example, a similar array of chemicals was instrumental in the origin of life.

When Huygens finally makes contact with Titan in November 2004, it will spend about two and a half hours boring through the atmosphere. "We'll drop it into Titan and it will slow down," says Dennis Matson, chief scientist for Cassini/Huygens and a senior scientist at the Jet Propulsion Laboratory. "When it slows enough it will deploy a parachute. And as it descends into the atmosphere, it will make a variety of measurements of the atmosphere's physical and chemical properties. Then it will reach the surface, where it may or may not send us back information about surface composition and properties." Should it land in liquid, the probe can sample

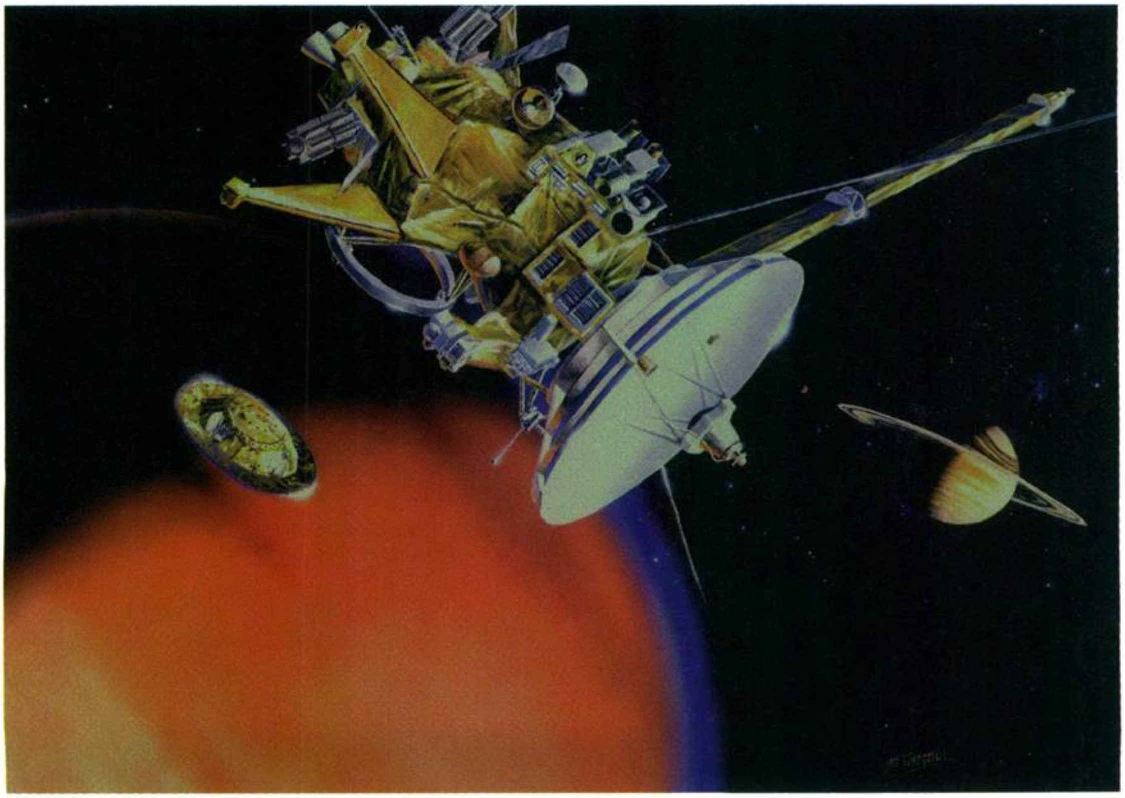
Conditions on Titan's surface may resemble those on Earth 4.5 billion years ago. NASA/JPL that and continue to function. Estimated battery power assures about three minutes of operation from the surface, but with luck, Huygens could continue to relay information for up to an hour.

After biding the seven years time between Earth and Titan, a fancy little chemistry lab within Huygens will spring to life once the probe hits the atmosphere. The lab includes a gas chromatograph and a mass spectrometer — not bad for a capsule only nine feet across. With these instruments, the probe should be able to identify the chemicals it runs into. Huygens also has an aerosol collector and "pyrolyzer." When the probe gets low enough, it expects to find aerosol particles in the air for the collector to grab. It then will feed the aerosols to the pyrolyzer — a high-tech oven, which will cook them and forward the resulting gas to the chromatograph and spectrometer for final analysis. The probe will transmit its findings back to Cassini, which in turn will ultimately beam the data back here. Earthbound scientists will then be able to get a much clearer picture of just what kind of chemistry is going on on Titan. In addition, Huygens will image the atmosphere and surface, measure temperatures, and reveal a thing or two about Titan's winds as probes record their affect on its descent.

Knowing about Titan has value for its own sake, but one way to look at this mission is that Cassini/Huygens is not just a spaceship to Saturn — it's also a time machine to early Earth. "Titan provides us with an opportunity to travel backwards in time," a team of mission scientists wrote. Jim Ferris, professor of chemistry at Rensselaer Polytechnic Institute in Troy, New York, and the former president of the International Society for the Study of the Origins of Life, attempts to recreate a tiny bit of Titan in the laboratory so he can study its chemistry. He agrees that in a sense, this amounts to time travel. "Here's a system in our own solar system where you're starting with simple molecules and building up more complicated ones," Ferris notes. "And that's presumably what happened on the early Earth. I'm not saying conditions on Titan are exactly the same as those that were on the early Earth and led to the origin of life. But it's sort of a laboratory analog of the early Earth that has been going for 4.5 billion years."

Based on our best reconstruction of how life appeared on Earth, it is an ironic twist of nature that oxygen, fundamental to the maintenance of most life, cannot be present at the inception of life. Initial life produced the oxygen that drove subsequent life. That process, however, completely changed Earth's chemistry, destroying much of the evidence for life's jumpstart. But some similar evidence may still exist, on Titan. "The question of how life formed on Earth makes Titan a particularly attractive place," says Jonathan Lunine, an interdisciplinary scientist on Huygens and professor of planetary sciences at the University of Arizona. "There may be others who want to go there to actually look for life today, but I think a careful consideration of what the environment of Titan is like suggests that it's a much more promising place to search for how the transition from chemistry to biology occurs."

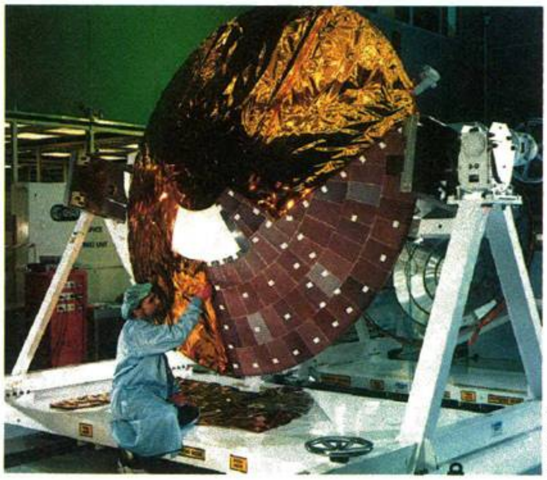
Titan is that promising place for multiple reasons. All the life we know depends on



On November 6, 2004, the six-ton Cassini spacecraft will release the Huygens lander. Huygens will coast for 22 days before it slams into Titan's hazy upper atmosphere at a speed of 13,725 miles per hour.

NASA/JPL/Michael Carroll

Built by the European Space Agency, the 770-pound Huygens probe carries six scientific instruments.

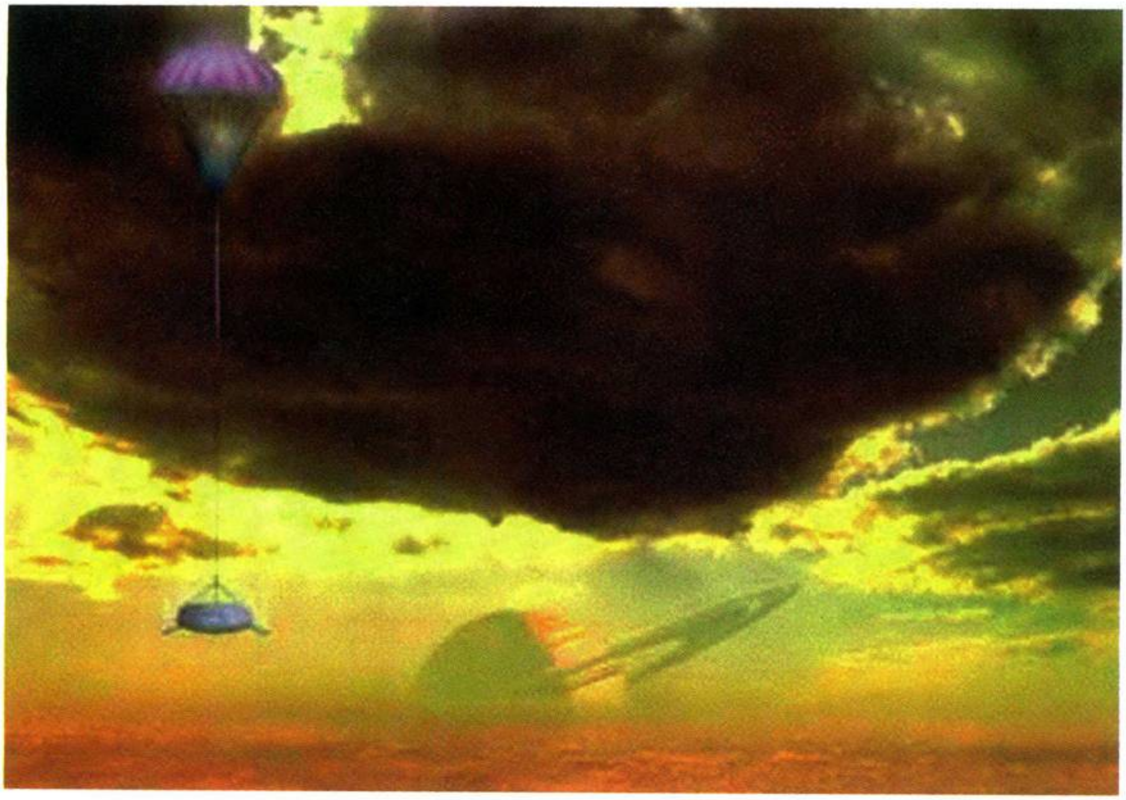

NASA/JPL

molecules that include highly versatile carbon atoms, able to connect to each other in long, complicated chains. The chemistry of compounds containing carbon is known to chemists as organic chemistry. (While farmers may use the word "organic" to mean pesticide-free, pesticides themselves are often organic molecules to chemists.) One reason then that Titan fascinates those looking for clues to how life comes into being is that it has scads of interesting organic chemistry. On Titan, however, organic chemistry appears to be going on without concurrent life.

Of course, other worlds have atmospheres filled with interesting materials. Mars and Venus do, but the Titan atmosphere's chemistry appears to be much closer to the early Earth's. The jovian planets no doubt have interesting chemistry going on in all that gas, but with no surfaces they squander the opportunity to concentrate organic compounds on a platform, as happened on Earth and probably on Titan as well. Titan also receives energy, as ultraviolet light, charged electrons from Saturn's magnetosphere, cosmic rays, and impacts. The additional presence of volcanoes, supplying transient heat, cannot be ruled out. "So Titan has the organic material, the energy sources, the 4.5 billion years, the solid surface," says Lunine. It also has plenty of space on its surface, being bigger than Mercury and Pluto — only Jupiter's Ganymede is a bigger moon. "So there are temporal and spatial scales available that we simply cannot reproduce in the laboratory."

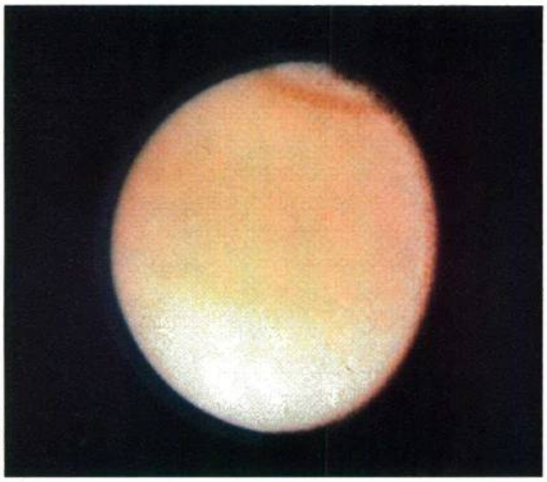
Part of the remaining mystery surrounding Titan is due to the heavy haze that kept the Voyagers from seeing the surface. The haze itself, however, did catch the eye of the late Carl Sagan, who attempted to duplicate Titan's conditions in the lab. He and colleagues then introduced the kinds of energy sources available to Titan. (Experiments in the early 1950s had revealed that light and lightning could have transformed simple molecules into complex molecules associated with life here on Earth.) The result was a dark organic solid that Sagan dubbed tholin, Greek for muddy. The optical qualities of tholin turned out to be remarkably similar to those of Titan's haze. What Sagan saw in the lab is probably what is happening, on a massive level, on Titan.

"Carl's lab was the leading lab for simulating organic chemistry in Titan's atmosphere for a long



After deploying its parachute, Huygens will sample the atmosphere's chemical and physical properties on its way down to the surface.

European Space Agency



NASA/JPL

Titan is the only satellite in the solar system with a thick atmosphere. It's predominantly nitrogen — like Earth's.

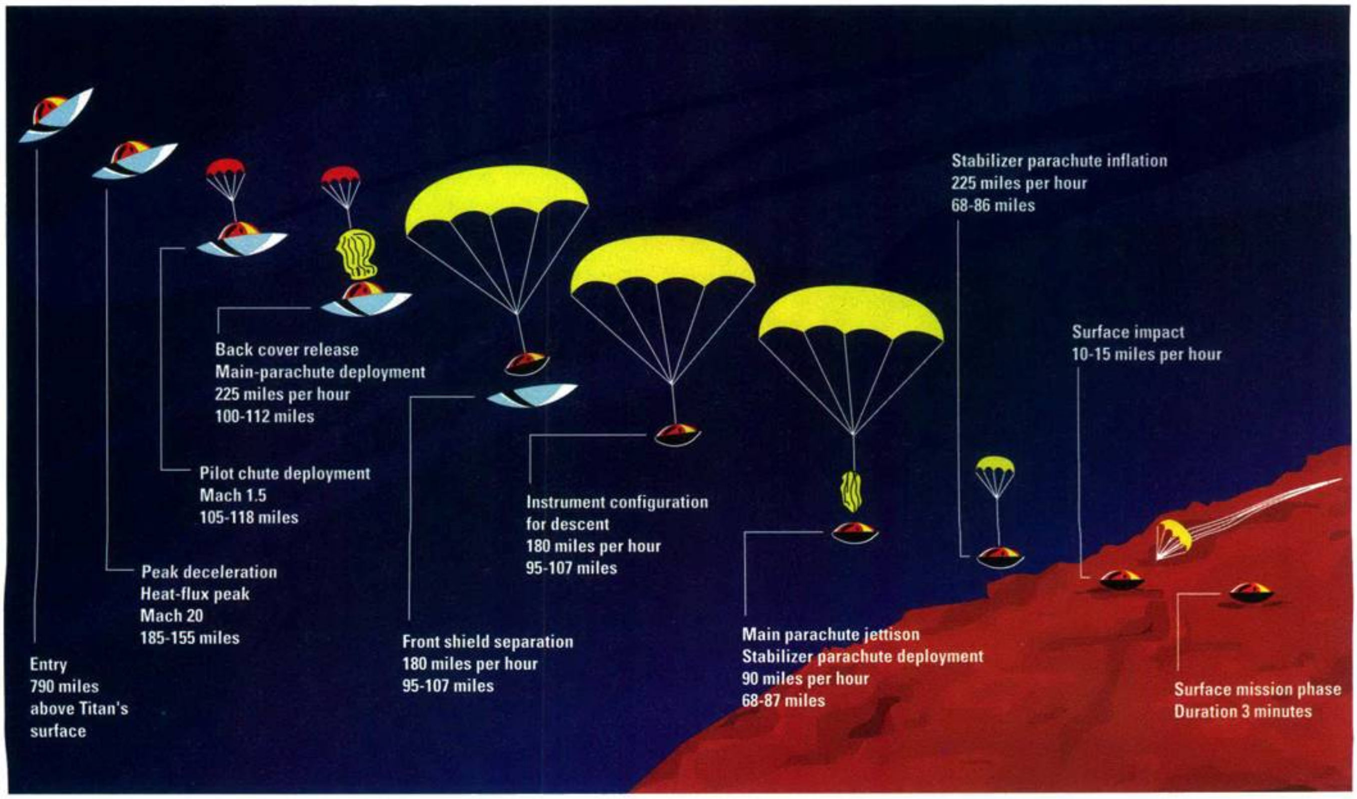
time," says Chris Chyba, assistant professor of planetary sciences at the University of Arizona. Chyba was once Sagan's student at Cornell University, just as Sagan had been the student of Gerard Kuiper, who discovered that Titan in fact had an atmosphere. According to Sagan, organic molecules must have constantly rained down from the upper atmosphere as new tholin formed. If this process has been going on for four billion years, the still enigmatic surface may be covered by hundreds of meters of tholin.

Huygens should tell us much more about the organic sludge and about the surface in general. Ground-based observations indicate that the surface probably varies quite a bit. At one point, researchers believed that an ocean of liquid ethane, another hydrocarbon, might exist on Titan, although that idea has fallen out of favor.

"We don't know what the surface is like," Owen says. "We can imagine — look at Ganymede, another big satellite of comparable size. So we expect that the basic surface material is probably water ice. There probably have been impact craters. But what's interesting to us is the subsequent modification that's taken place in this very special environment, where we can have liquid hydrocarbons on the surface and all these aerosols raining down. In other words, it's what you might think of as a flammable world. The whole landscape is something that could burn, with water-ice underneath it." But it won't ignite, because of the absence of oxygen in the atmosphere.

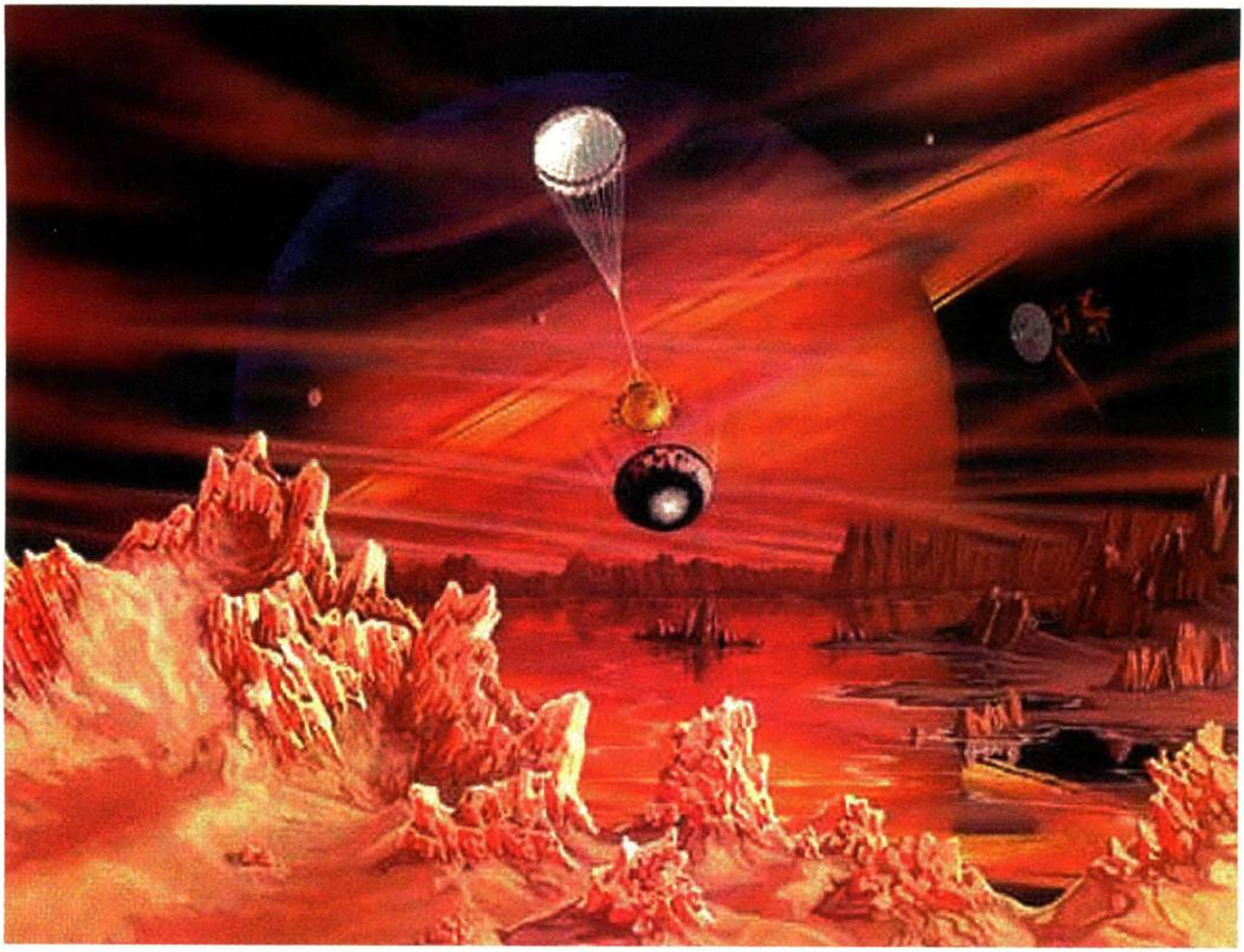
This combination of hydrocarbons and energy sources, along with the utter lack of any oxygen, is what will keep those interested in how planets come to support life on the edge of their seats for the next seven years. "I'll be taking vitamins and trying to jog," Lunine says of his own plans to survive to see the data.

So with all this talk about conditions that appear primed for the creation of life, might Huygens surprise everyone and take a picture of something wriggling by on Titan's surface? "It would have to be something that can wriggle at 95 degrees Kelvin," notes Ferris. And that's extremely cold for life. Liquid water is, as Earth shows, a wonderful solvent in which to carry on the chemistry of life. All the water on Titan is locked up as ice by the cold. And while some organics there are


Entry
790 miles
above Titan's
surface
Peak deceleration
Heat-flux peak
Mach 20
185-155 miles
Pilot chute deployment
Mach 1.5
105-118 miles
Back cover release
Main-parachute deployment
225 miles per hour
100-112 miles
Front shield separation
180 miles per hour
95-107 miles
Instrument configuration
for descent
180 miles per hour
95-107 miles
Main parachute jettison
Stabilizer parachute deployment
90 miles per hour
68-87 miles
Stabilizer parachute inflation
225 miles per hour
68-86 miles
Surface impact
10-15 miles per hour
Surface mission phase
Duration 3 minutes

After hitting Titan's upper atmosphere, Huygens will take 2½ hours to descend to the surface.

NASA/JPL/
Astronomy: Terri Metzger



Huygens will impact Titan's surface at a speed of only 10 to 15 miles per hour. In reality, the moon's thick, hazy atmosphere would obscure the view of Saturn from its surface.

NASA/JPL

HOW TO SPOT SATURN AND TITAN

The bright planet Saturn is well-placed for observing this month, lying near the meridian at mid-evening. It shines at magnitude 0.4 and graces the constellation Pisces, setting about three hours before sunrise. With a telescope, it's easy to see the planet's rings and, appearing as a magnitude 8.4 "star," Saturn's moon Titan, which orbits the planet at a distance three times greater than the edge of the rings.

liquid at even Titan's temperatures, carrying on the chemistry of life in them remains problematic.

"It's a question of driving chemical reactions at a useful speed when you're down there at 95 K," says Owen. Commentators concerned with the origin of life on Earth often talk about the nutrient-rich liquid from which the first cells sprang as the primordial soup. "I like to think of the sludge that's accumulating on Titan," says Owen, "as the primordial ice cream." Getting life going on Titan may then be like trying to start your car on a brisk January morning in Minneapolis — the right chemistry is all in place, but it's just too cold.

Perhaps even more poignant is the fact that impacts have no doubt warmed up small sections of Titan to the point where liquid water may have persisted, confined, for up to a thousand years at a time. Add the complex organics we know exist on Titan and the ultraviolet light or particle bombardment that could initiate chemical reactions, and the first steps toward life may have gone on countless times in isolated pools, only to stop cold when ice won the day. "I think that's probably what happens," Lunine says. "If one could explore Titan's surface in detail in many places, one might see particularly attractive areas where there was liquid water at some time and a rather elaborate set of molecules could have been constructed."

In one of those now frozen pools on Titan, future probes or even people may uncover combinations of atoms that will tell us more about how we came to be. The writer Henry Miller said of travel, "One's destination is never a place, but rather a new way of looking at things." More than anything else, the opportunity to find a new way of looking at ourselves here on Earth truly drives our travels to other worlds. ■

Steve Mirsky is a science writer in New York City, where tantalizing signs of intelligent life have been found, but not yet verified. His favorite movie is Clash of the Titans.

ask Astro

Q: Could the ice ages be caused by the solar system drifting through irregular clouds of interstellar debris? *— Hallard C. Moyer, Homewood, Illinois*

A: Although interstellar clouds may at first seem a reasonable explanation for the ice ages, this hypothesis cannot explain one of their most startling features: periodicity. For nearly a million years, ice ages have hit Earth's northern latitudes every 100,000 years. It is hard to understand how interstellar clouds, which are clumpy and irregular, could cause such a periodic phenomenon.

Instead, most ice age experts support the Milankovitch theory, which invokes three periodic changes in Earth's orbit and tilt: the ellipticity of Earth's orbit, which varies every 100,000 years; the size of Earth's axial tilt, which varies every 41,000 years; and the direction of that tilt, which varies every 23,000 years. Changes in these three quantities conspire to alter the amount of sunlight that reaches the Northern Hemisphere during summer. According to the theory, when northern summers are cool, ice accumulates, glaciers stampede south, and Earth experiences an ice age.

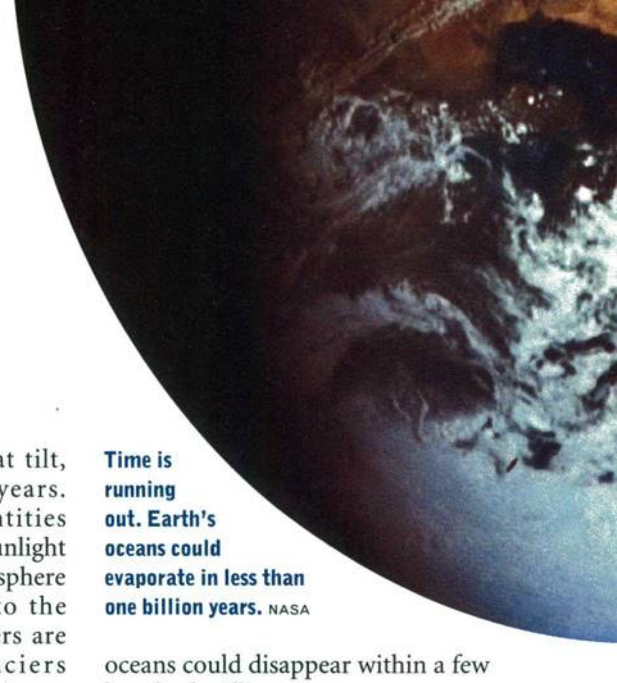
It would be bad news for life on Earth if the solar system wandered into an interstellar cloud such as this. However, Earth's ice ages are periodic, meaning some other mechanism must be responsible. Anglo-Australian Observatory/ Photography by David Malin

For an entertaining exposition of this theory, see *Ice Ages: Solving the Mystery* by John Imbrie and Katherine Palmer Imbrie (Enslow Publishers, 1979). — *Ken Croswell*

Q: How long will it be before the sun becomes too luminous to support life on Earth? *— Richard Cahall, Bend, Oregon*

A: The sun will remain in its normal state for another five billion years before it expands into a red giant. However, life could be in trouble long before that time.

The sun is currently brightening by about one percent every 100 million years as it converts hydrogen into helium, which makes the core denser and hotter. If the sun brightens by as little as ten percent it may destabilize the oceans by allowing water vapor to reach the stratosphere, where it can be broken apart by solar ultraviolet radiation. Hydrogen, being the lightest element, escapes into space, so the oceans could disappear within a few hundred million years.



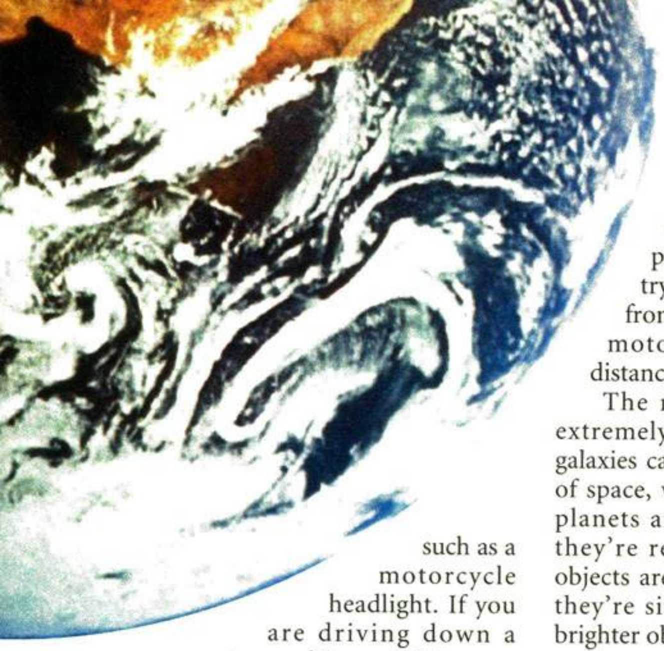
Time is running out. Earth's oceans could evaporate in less than one billion years. NASA

Even before this occurs, there is another feedback that could be fatal for many types of life. As Earth's surface temperature increases, atmospheric carbon dioxide levels probably decrease in response to faster weathering of silicate rocks on the continents. Calculations indicate that carbon dioxide levels could be drawn down below the critical threshold for carbon-3 photosynthesis in only about 500 million years. As 95 percent of the world's plants use the carbon-3 photosynthetic pathway, this would be disastrous for most land-based ecosystems. Marine life and terrestrial carbon-4 plants, including corn and many tropical grasses, would fare much better at low carbon dioxide levels, but an ecosystem based on these plants would be very different from the one today. — *James Kasting, Penn State University*

Q: If the Hubble Space Telescope can detect galaxies ten billion light-years away, why can't it detect the planet orbiting 51 Pegasi, which is only 50 light-years away? *— Linda Thomas, Minneapolis, Minnesota*

A: Have you ever seen those annoying bright searchlight beams that car dealerships shoot high into the night sky? They are trying to attract potential customers from many miles away. Think of a galaxy ten billion light-years away as one of those searchlight beams.

Now consider a light that's fairly bright, but not as bright as a searchlight,



such as a motorcycle headlight. If you are driving down a country road late at night, you can see the headlight perhaps a mile in the distance, not nearly as far as you could see the searchlight beam. The star 51 Pegasi would be that headlight.

What about 51 Pegasi's planet? The planet doesn't shine with its own light, it only reflects a tiny portion of the star's light, so the star is millions of times brighter than the planet. The planet would be akin to a marble.

Remember that the planet is orbiting very close to 51 Pegasi, at only 1/20 the Earth-sun distance. From our distance of 50 light-years, 51 Pegasi and its planet are separated by the apparent width of a penny as seen at 800 miles. Trying to see the planet in the star's glare is like trying to see the reflected light from the marble right next to the motorcycle's headlight from a distance of one mile.

The moral of the story is that extremely luminous objects such as galaxies can be seen across vast depths of space, whereas dim objects such as planets are hard to observe even if they're relatively nearby. And dim objects are especially difficult to see if they're sitting right next to a much brighter object. — *Robert Naeye*

Q: What causes the tail of Comet Hale-Bopp to split into two distinct parts and why do the parts move at different angles rather than flow with the direction of the solar wind? — *Walt Sherry, 108 Mile Ranch, British Columbia, Canada*

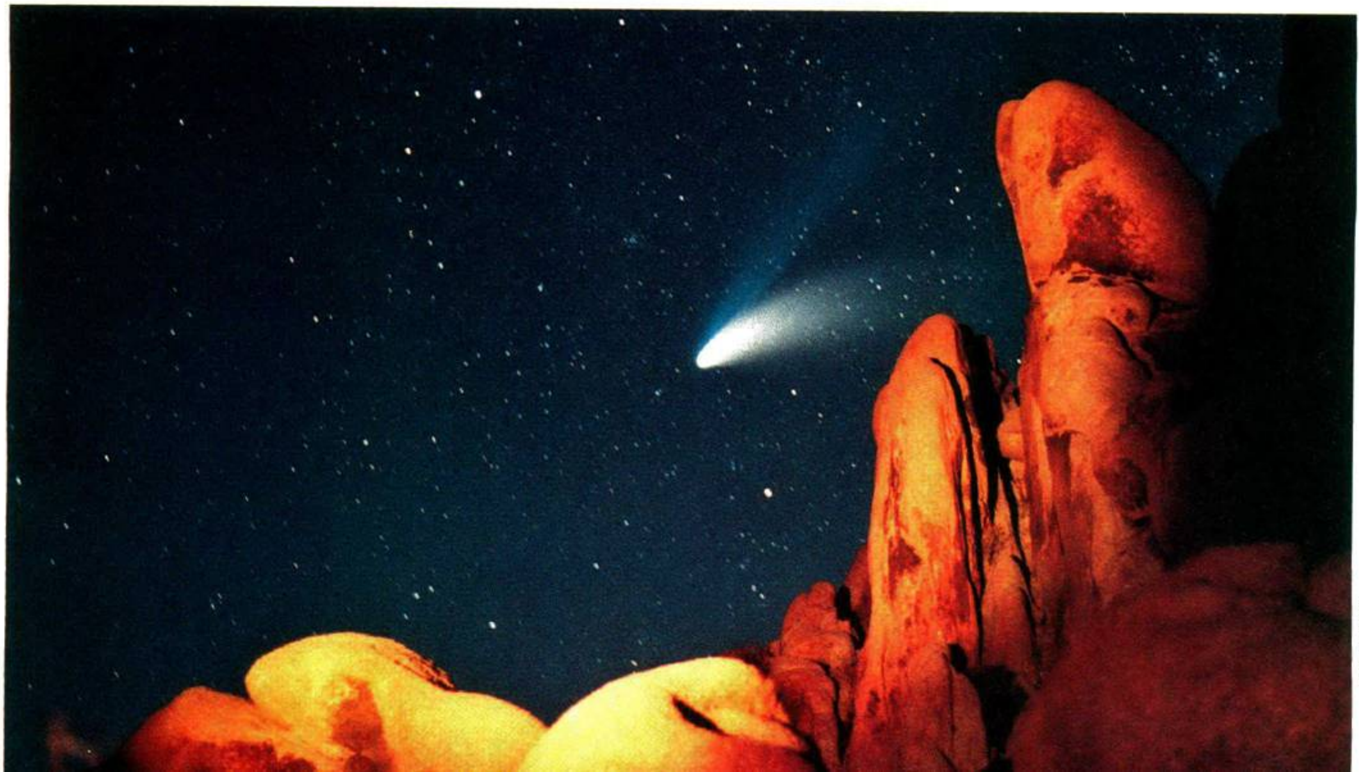
A: What you're seeing with Hale-Bopp (and other active comets) is an ion tail and a dust tail. The searing heat of the sun evaporates ice on the "dirty snowball" that is the comet's nucleus, forming a huge cloud of gas around the nucleus called the coma. Solar ultraviolet light ionizes this gas (causing the atoms in the gas to lose one or more electrons). The charged subatomic particles of the solar wind push the ions straight back to form a tail, so the ion tail always points away from the sun like a windsock on a gusty day. It appears blue because that's the predominant wavelength of light radiated by the ions.

The yellow-white tail comes from dust particles liberated along with the gas from the comet's nucleus and gently pushed away from the nucleus by the pressure of sunlight. The uncharged dust particles are unaffected by the charged solar wind particles, so the dust particles follow their own orbits around the sun, slowly spreading out along the comet's path. The dust tail's yellow-white color comes from reflected sunlight.

Hale-Bopp arched above the sun from our perspective, so the twin tails we saw were the dust tail trailing along behind the comet and the ion tail pointing directly away from the sun. — *John Shibley*

CONTACT INFO

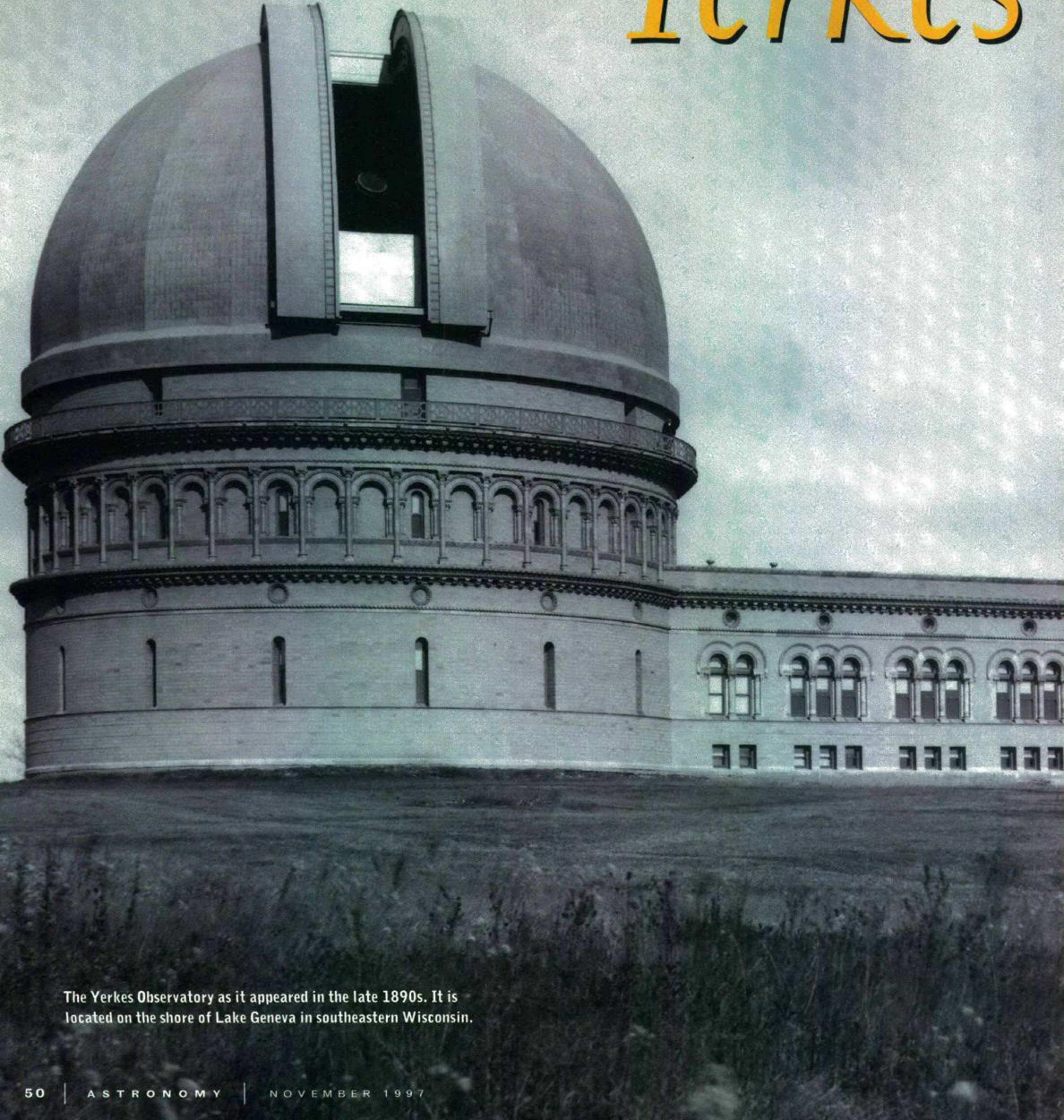
Send your questions via e-mail to: askastro@astronomy.com; or write to: Ask Astro, P.O. Box 1612, Waukesha, WI 53186. Please tell us your full name and where you live. *Astronomy* regrets that due to the large volume of mail, we are unable to publish answers to all questions or respond to each one individually.



Wally Pacholka

Comet Hale-Bopp sprouted two tails, a yellow-white tail consisting of dust and a blue tail consisting of gas. A faint third tail, made of sodium ions, was discovered by scientists but does not appear in most photos.

Yerkes



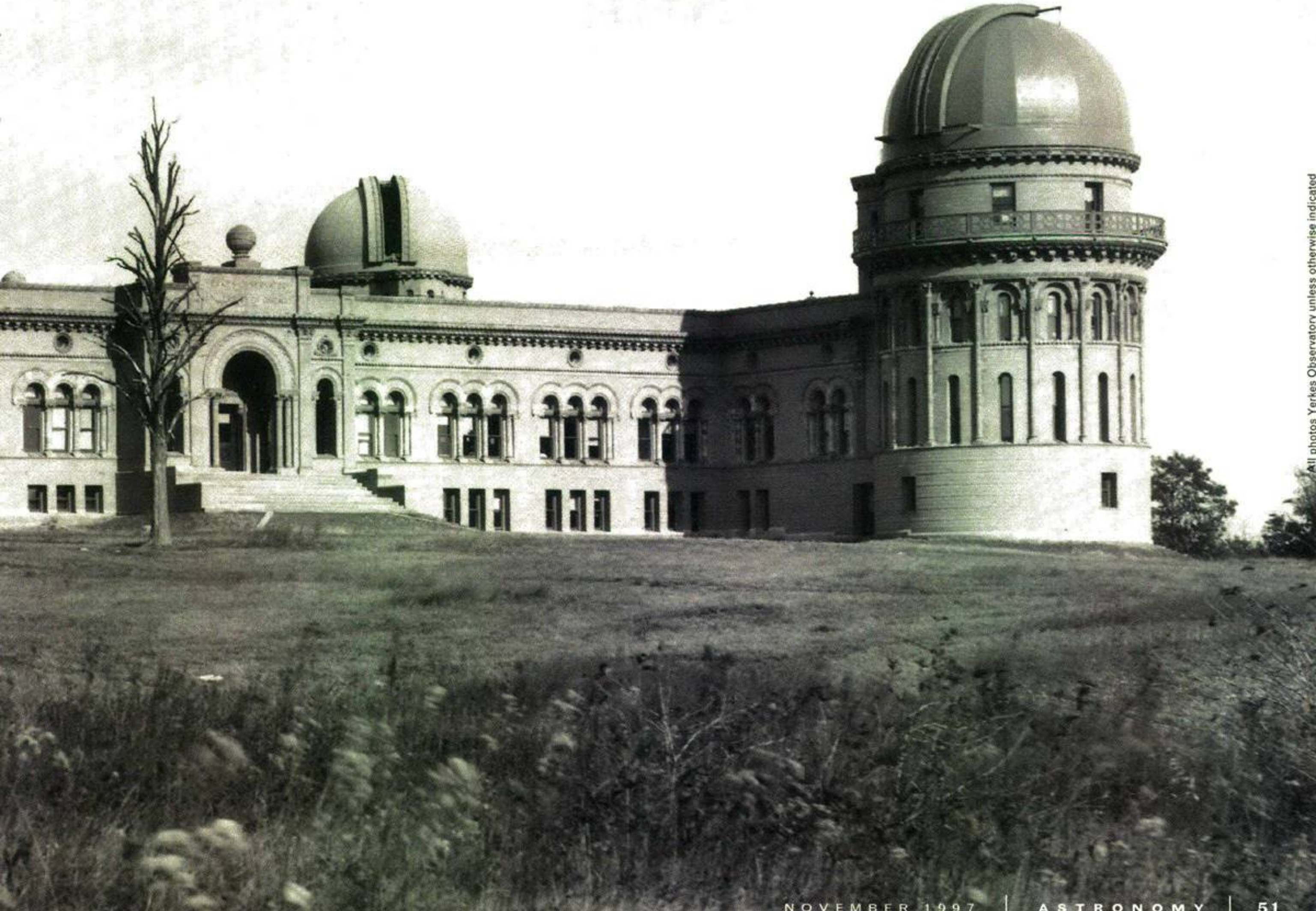
The Yerkes Observatory as it appeared in the late 1890s. It is located on the shore of Lake Geneva in southeastern Wisconsin.

OF LEGENDS

at 100

Named after the shady financier who funded it, the Yerkes Observatory survived a near disastrous accident to become one of America's great observatories.

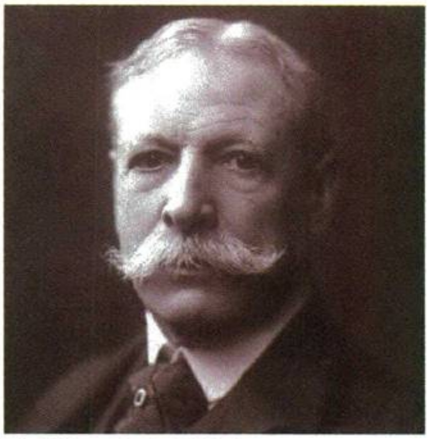
by **William Sheehan**



All photos Yerkes Observatory unless otherwise indicated

AT WILLIAMS BAY, IN SOUTHEASTERN Wisconsin, on a beautiful crisp October day in 1897, the Yerkes Observatory began its career as one of the proudest institutions of American astronomy. The observatory, with its stately Romanesque architecture, lofty domes, and beautiful manicured grounds on the shores of Lake Geneva, has, like any storied place, its ghosts.

Cigar-chomping double-star observer Sherburne Wesley Burnham observed here; so did E. E. Barnard, who discovered Barnard's Star, the star with the greatest proper motion known. In the 1910s, Edwin Hubble was a graduate student here, before going on to fame and fortune at Mt. Wilson. Russian-born astronomer Otto Struve, whose tenure as director began in 1932, brought to Yerkes such legendary scientists as Gerard Kuiper, Bengt Strömgren, and Subrahmanyan Chandrasekhar. All contributed enormously to what has always been the observatory's main work — understanding the physics and evolution of stars.



The Titan: Charles T. Yerkes

YERKES DID NOT HESITATE TO OBTAIN FRANCHISES FROM THE CITY COUNCIL BY BRIBERY, WHICH LED TO HIS BEING KNOWN AS THE "BOODLER."

EARLY DAYS

The Yerkes Observatory began as a dream of George Ellery Hale. Undoubtedly the greatest astronomer-entrepreneur who ever lived, Hale's dreams were always on a grand scale. Fortunately, he could usually afford them or, when he could not, find someone else who was willing and able to do so.

Hale was born in Chicago in 1868. The city's new skyscrapers needed elevators. Hale's father, William E. Hale, made his fortune supplying them. George Ellery Hale was an only child; his health was delicate, and after he came down with typhoid fever at the public school, his doting parents sent him to the exclusive Allen Academy. An early interest in science led him to seek out S. W. Burnham, a hard-bitten, wiry, self-made man who worked as a Chicago court reporter by day and discovered double stars with his 6-inch telescope by night. But Hale was not interested in the old methods of observers like Burnham. "I was born an experimentalist," he later recalled, "and I was bound to find the way of combining physics and chemistry with astronomy."

In pursuit of this goal, Hale studied physics at MIT and did volunteer work in spectroscopy with E. C. Pickering at the Harvard College Observatory. After his graduation and marriage, and a honeymoon highlighted by a visit to the Lick Observatory in California, he and his wife moved in with his parents in Chicago. Upon his return to Chicago, Hale carried out research from his own private observatory, equipped with a 12-inch refractor and laboratory that his father built for him next to the family mansion in Kenwood.

He was there in February 1891, when the University of Chicago's "boy president" William Rainey Harper — who received his Ph.D. at age 18 and became president of the university at the tender age of 36 — approached him about joining the faculty. Harper's offer was contingent on Hale's turning over his Kenwood observatory and laboratory to the university. The University of Chicago had just been organized in Hyde Park, only two miles from Hale's Kenwood home. It was liberally funded by Standard Oil tycoon John D. Rockefeller, and energetically led by Harper.

Hale indignantly turned Harper's first offer down; but eventually Harper managed to smooth things over, and Hale reconsidered and accepted. His father also agreed to turn over the Kenwood observatory, provided his son still wanted the job after a year and Harper was successful in raising funds for an even larger telescope within two years.

Hale and Harper wanted to "give the thing a big start from the first." On a trip east in the summer of 1892, Hale learned of the availability of two partly finished 40-inch glass disks which had originally been purchased by a group of Southern California promoters hoping to "lick the Lick," with its 36-inch refractor, with an even larger telescope of their own. The investors went broke when the land boom bubble in Los Angeles burst. This was just the sort of opportunity Hale could not resist. On his return to Chicago, he and Harper arranged for an interview with financier Charles Tyson Yerkes.

THE TITAN

Yerkes had started his career in high finance in Philadelphia, where he had been jailed after being caught red-handed misappropriating some of the city's funds. He moved to Chicago and eventually made a vast fortune by establishing a mass-transit empire in Chicago, the elevated ("el") trains. Again his methods were sometimes questionable at best; when necessary, he did not hesitate to obtain franchises from the city council by bribery, which led to his being known as the "Boodler."

In the fall of 1892, he was in an upbeat mood — he had just married a chorus girl, whom Harper described as "the most gorgeously beautiful woman I have seen for years," and Harper thought him "red hot" to become the "owner" of the world's largest telescope. Yerkes agreed to fund the telescope, though only after learning that he did not have to advance any money. He was then having difficulty obtaining further funds for his transit empire, whose further expansion was being founded on a mountain of debt. He shrewdly judged that the telescope would improve his sullied public image and his chances of obtaining further credit. Indeed, he confided to an associate that by the time the telescope was finished, "his fortune would be fully made, or else he would be completely 'busted'."

For the site of the observatory, Hale and Harper considered several locations in northern Illinois and one in southeastern Wisconsin. Finally, Harper decided on the one on Lake Geneva — not least because many well-to-do Chicagoans had summer homes there, which Harper realized would make fund-raising for the new observatory easier. S. W. Burnham examined the site and decided the seeing conditions were satisfactory (he did not come in winter). Thus the Yerkes Observatory became the last great observatory built near sea level.

The Boy President: William R. Harper

The university architect, Henry Ives Cobb, worked out the design of the observatory in splendid Romanesque style. The large tower at the western extremity, designed to house the 40-inch telescope, was capped by a dome 92 feet in diameter. All the buildings were constructed of brown Roman brick, with gray terra-cotta ornaments. Architecturally, it is superb.

There is one curious feature; the columns outside the main entrance were decorated with a bee stinging a man on the nose. Some say this is supposed to represent Rockefeller being stung for the money. Another figure is almost certainly a caricature of the corpulent Harper. Hale worried that the bees would offend someone, so he peremptorily summoned a stone-mason to chisel them off at once. One can still see traces of the bee that used to be.

NEAR DISASTER

As the observatory's first director, Hale's initial task was to assemble a staff. He hoped to get James E. Keeler, the pioneer spectroscopist then at Pittsburgh's Allegheny Observatory, but he was unable to do so. He did get the young Walter Sydney Adams, later the director of Mt. Wilson Observatory, and the Dartmouth-trained spectroscopist Edwin Brant Frost. He was also joined by skilled optician George Willis Ritchey. But the most famous members of the original staff were the two classically trained astronomers formerly at Lick Observatory — S. W. Burnham and E. E. Barnard. The latter had made a name for himself as the discoverer of the fifth satellite of Jupiter and as a pioneer comet and Milky Way photographer.

The mounting, tube, and floor of the great telescope were built by the Cleveland, Ohio, firm of Warner and Swasey and narrowly escaped damage by fire at the Columbian exhibition in 1893. The 40-inch lens took longer; it was finally ground and polished and then escorted — personally — by famed optician Alvan G. Clark from his Cambridgeport, Massachusetts workshop. The lens arrived at the Williams Bay train platform on May 19, 1897. The next day, Clark unpacked and fitted the lens to the 62-foot-long tube.

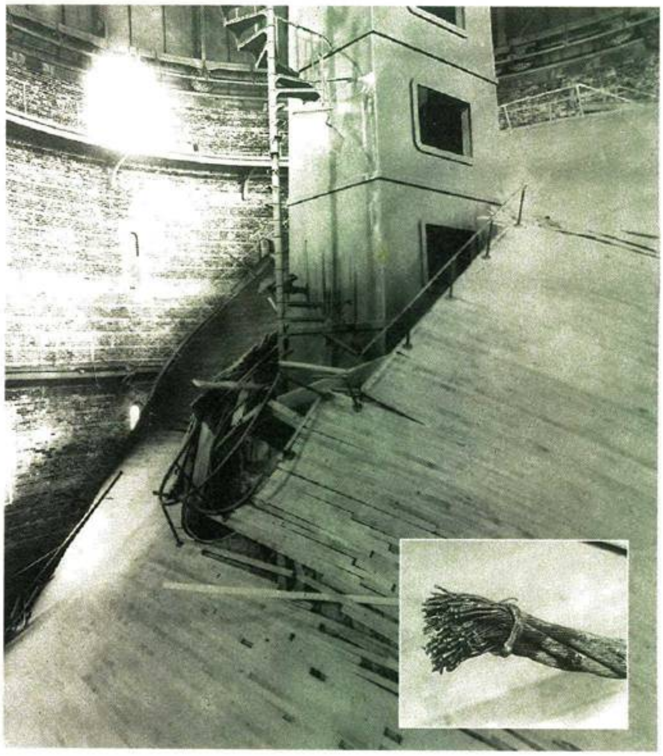
During the telescope's first light, Barnard saw a new optical companion of the bright star Vega. The observation was of no scientific importance, but Hale, ever the opportunist, wrote triumphantly to Yerkes that it had effectively demonstrated the preeminence of the Yerkes telescope. By this time, the Titan's interest in his observatory had begun to wane; he was engaged in a long, and ultimately unsuccessful, battle with the Illinois legislature to retain rights to the franchises of the Chicago elevated streetcar lines and was also absorbed in constructing a $2-million mansion on New York's Fifth Avenue, complete with marble staircase, aviary, and private art gallery.

On May 25, 1897, a special train carrying trustees, faculty, and friends of the University of Chicago arrived at the observatory for a peek through the new telescope. That evening the wind was gusty, but the guests, beginning with Harper, eagerly awaited their turn to get a glimpse of Jupiter. Next day, Clark — satisfied that his work was finished, but unbreakfasted and on foot — returned to the train station. The Hales failed to see him off; they overslept.

Hale had hoped to open the telescope to public viewing one night a week. Yerkes was emphatically opposed. He had in all spent half a million dollars on the telescope (which was *a lot* of money back then), and insisted that "no one be allowed, except those in charge, to approach anywhere near the glass . . . In fact, every precaution should be taken to keep visitors away from it . . . It is there for scientific research and for that only!"

The astronomers began their research almost at once. On May 28, Hale observed with the 40-inch telescope until just after midnight, then yielded it to his personal assistant, Ferdinand Ellerman, and E. E. Barnard. In order to get a view of the Swan Nebula (M17) in Sagittarius, they raised the moveable floor to within six inches of its highest point, and as day began to break they gave up observing and left the floor in this position "for the convenience of some workmen

Shortly after the observatory's construction was completed, part of the moveable floor fell 45 feet, delaying the opening ceremony by several months. Fortunately, nobody was injured and the telescope survived unscathed. Inset: Guilty as charged: the snapped cable responsible for the crashing floor.



who were to attend to the tube in the morning," Barnard later recalled.

The astronomers had hardly left the dome when one of the workmen coming to the observatory heard a loud crash. One of the cables suspending the floor had given way, and the floor had dropped 45 feet on that side. The entire floor was in ruins. Barnard and Ellerman had narrowly escaped death. So too, Barnard reflected, had the cream of the University of Chicago — Harper, some 30 or more trustees, and many prominent men of the university — who had stood on that now-wrecked floor only a few nights earlier. News of the catastrophe did claim one indirect casualty; it seems to have been too much for old Clark, who, worn-out from his trip to Williams Bay, died of a stroke a week later.

Miraculously, the leviathan telescope, which was mounted on a huge metal pier, seemed to have survived unscathed. But no one could say for sure until the lens was examined; everyone worried that vibrations rippling through the pier could have cracked the lens. A daring soul climbed onto the dome and peered down through the slit — the glass was apparently undamaged, though it was still impossible to say for sure until it could be tested by starlight.

This could not be done until the floor had been replaced. Finally, in mid-August, the floor was finished, and the moment of truth arrived. The telescope was swung around to the stars. "To our consternation," Barnard recalled, "there was a great, long flare of light running through every bright star we examined." Only the next day could the lens be examined. It had not been shocked by the falling floor after all. Instead, just back of the glass in the tube, Hale noticed a mass of spider webs. Barnard wrote: "During the time the tube remained at rest, while the new floor was being put in, a solitary spider had crawled up the great telescope in the direction of the light; only to find his egress barred by the great window. As the days went by and he slowly starved to death, he spun his web, perhaps as a signal of distress or maybe in the hope that some unlucky fly might get in through the glass he could not get out of." All it took was a feather duster to get the mighty glass to perform perfectly again.

The Astronomer-Entrepreneur: George E. Hale

HALE STOOD THERE IN SILENCE, LOOKING UP AT THE GREAT REFRACTOR. FINALLY HE REMARKED, "NOBLE INSTRUMENT." THEN HE LEFT, NEVER TO RETURN.

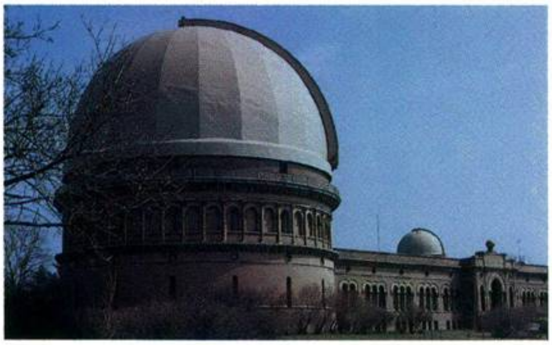
DEDICATION

The official dedication of the observatory — delayed by the accident — finally took place on October 21, 1897. Seven hundred guests, including trustees and faculty of the university — and the Titan himself — were on hand. The dedicatory exercises were held in the great dome. Yerkes made a few remarks: "I . . . with the fullest feeling of satisfaction and pleasure turn over to you this structure with all of its contents, feeling satisfied that it is now in the best of hands and that the labors here will be serious, conscientious, and thoroughly done. I feel that in your attempts to pierce the mysteries of the universe which are spread before you by our great Creator, the enthusiasm of your natures will carry you to success." Thunderous applause.

In 1904, Hale left for California to found Mt. Wilson Observatory and Edwin Brant Frost took over as director. Hale paid his last visit in 1932. By then, he had suffered from nervous problems for many years and increasingly found life endurable only by avoiding people and spending time in his private solar observatory in Pasadena, which he had built partly out of nostalgia in order to recapture the joys of his youth. He had seen Mt. Wilson build its 60- and 100-inch reflecting telescopes and had obtained funds for an even larger telescope which he did not live to see completed — the great 200-inch reflector on Palomar Mountain.

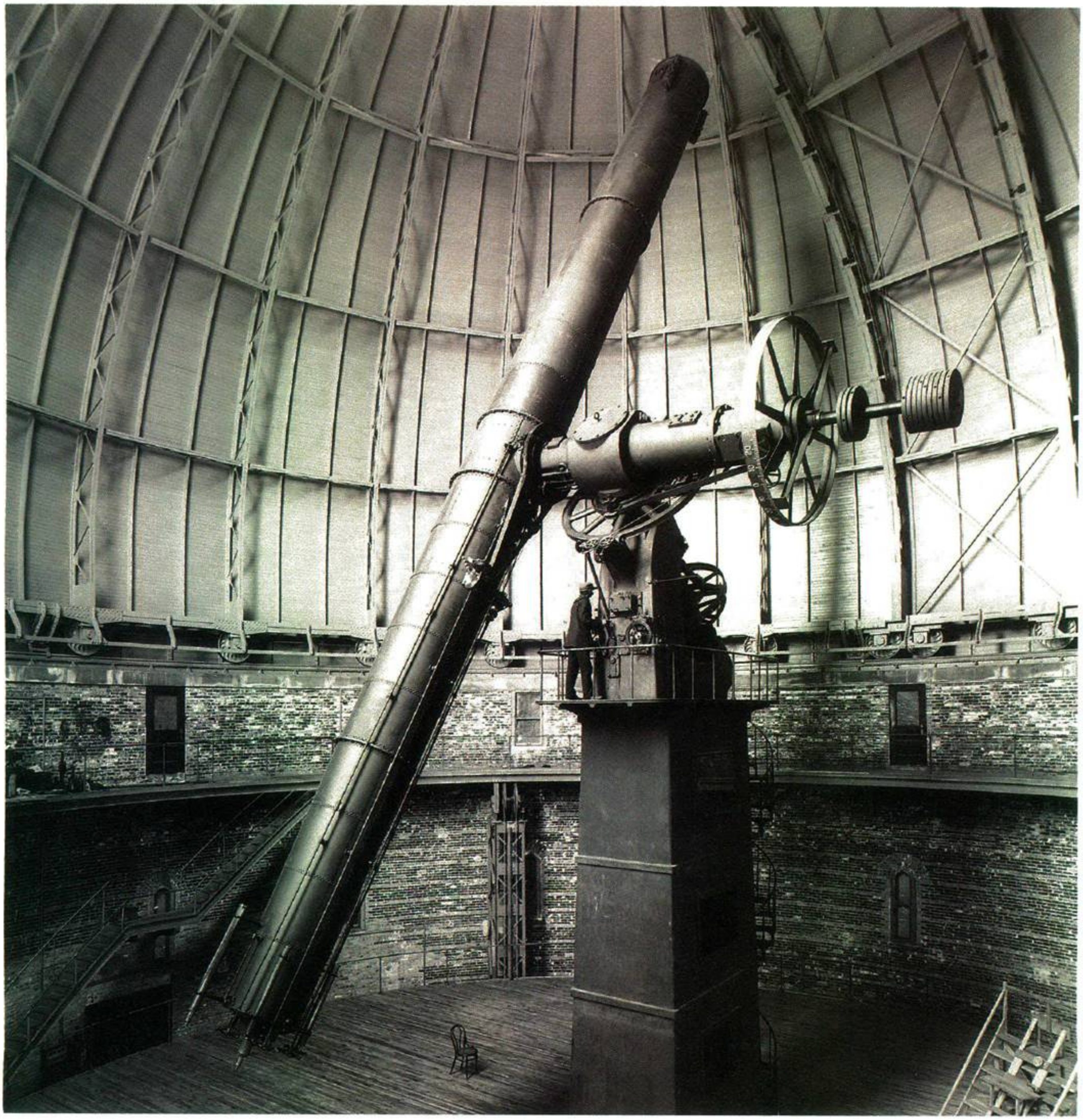
According to Yerkes staffer George Van Biesbroeck, "Hale came in, in a hurry as always, and after a brief visit with Frost, was about to head out the front door. Then suddenly he turned and said, 'I must have a look at the 40-inch.' He dashed up the stairs to the dome, opened the iron door, and entered. He took off his hat and stood there for a few moments in silence, looking up at the great refractor. Finally he remarked, 'Noble instrument.'" Then he left, never to return.

Tour Yerkes Observatory



Stephen A. Walther

Yerkes Observatory welcomes visitors on Saturdays throughout the year from 10:00 a.m. to 1:00 p.m. At 10:15, 11:15, and 12:15, a member of the observatory staff talks about the history and architecture of the building and takes visitors on a tour of the 40-inch refractor inside the 92-foot dome. The observatory has recently opened a museum that highlights the lives and work of 12 former Yerkes astronomers. The tour is free, although donations are requested. At the end of the tour, guests can stop by the gift shop. — *Dan Koehler*



S.W. Burnham stands at the controls of the magnificent Yerkes Observatory 40-inch refractor, which was ground and polished by Alvan G. Clark. It remains the world's largest refractor.

Frost became blind in later years, and tried to keep up with developments in astrophysics as best he could. But the pace of cutting-edge research fell off during Frost's stewardship. When he finally retired, shortly after Hale's last visit, Otto Struve was waiting in the wings to take over as director. Struve would lead the observatory into its Golden Age of research. It was once more in capable hands.

So the Yerkes Observatory was launched into its grand career on the oceans of science. It survived the crash of its floor, the departure of its energetic first director, and some lean years to persevere as one of the premier scientific institutions in the United States. Its 40-inch refractor has done admirable work and remains one of the most impressive of all astronomical instruments — a magnificent, "clipper-ship" of a telescope, with lean, graceful, classic lines. A century of efforts by some of the great astronomers and astrophysicists of their time have borne out Yerkes's fondest hopes for the telescope and the observatory he funded. **A**

William Sheehan is the author of The Immortal Fire Within: The Life and Work of Edward Emerson Barnard *(Cambridge University Press, 1995), a book that includes a great deal of Yerkes Observatory history. He recently co-authored* In Search of Planet Vulcan *(Plenum Press).*

Into the Moon's SHADOW

Most of the Western Hemisphere will see at least a partial solar eclipse this February, with a lucky few getting to witness totality.

by Richard Talcott

Everyone talks about the beauty of a total solar eclipse: the fiery red prominences arcing above the moon's limb, the wispy tendrils of the sun's corona, the delicate pinks and purples of twilight encircling the horizon. And beautiful they are. But the blazing glory of totality shouldn't blind anyone to the more subtle joys awaiting viewers of a partial eclipse. This coming February 26, observers in most of the Americas will see the moon take a bite out of the sun, while a lucky few get immersed totally in the moon's shadow.

The sun, moon, and Earth first line up in the early morning hours of the 26th. The moon's umbral shadow — the dark portion where the moon blocks all of the sun's surface from view — first touches Earth in the Pacific Ocean, roughly 2,000 miles southeast of the Hawaiian Islands. But the lighter penumbral shadow, where the moon covers only a part of the sun, stretches more than 4,000 miles from north to south. In fact, residents on the eastern half of the big island of Hawaii get to see the sun with a minuscule chunk taken out of it just as it pokes above the horizon.

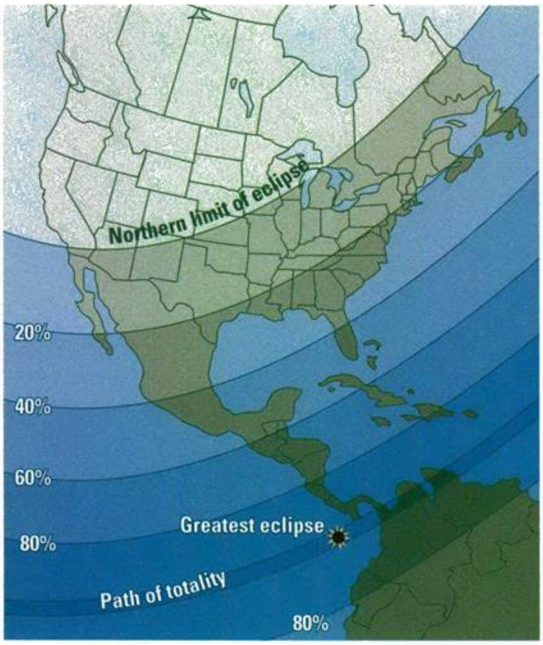
The umbral shadow races across nearly 3,500 miles of water in little more than an hour to make its first landfall in the Galápagos Islands. The islands in the path of totality — Isla Pinta, Isla Marchena, and Isla Isabela — are uninhabited wildlife sanctuaries with restricted access.

From there the umbra tracks across nearly a thousand more miles before reaching the Pacific coast near Panama's border with Colombia. Greatest eclipse occurs between the Galápagos and mainland South America, where totality last 4 minutes and 8 seconds and the umbral path measures 94 miles across. At the same time, just before 11:30 a.m. local time, the penumbral path stretches from the central United States to the northern border between Argentina and Chile.

After crossing northern Colombia and Venezuela, on this, the third time this decade that the moon's dark shadow has touched South America, the umbra enters the Caribbean Sea. Completely covering the islands of Aruba and Curaçao (and the northern tip of Bonaire) in the Netherlands Antilles, it then washes over the Leeward Islands of Montserrat, Antigua, and Guadeloupe.

Although a clear view of a totally eclipsed sun is without compare, a good partial eclipse will also provide lasting memories. Inset: Even partial eclipses offer exciting photo opportunities — if you scout out a pretty foreground and have a flair for the artistic.

Clark Snure; Inset: Frank Zullo



Astronomy: Elisabeth Rowan

Eclipse Times — February 26

City	Start	Mideclipse	End	Percent
Atlanta	12:00 noon	12:57 p.m.	1:54 p.m.	25%
Bogotá	11:17 a.m.	12:51 p.m.	2:20 p.m.	88%
Boston	12:36 p.m.	1:25 p.m.	2:11 p.m.	22%
Caracas	12:44 p.m.	2:16 p.m.	3:39 p.m.	93%
Guadalajara	9:52 a.m.	10:55 a.m.	12:04 p.m.	35%
Halifax	1:46 p.m.	2:34 p.m.	3:21 p.m.	24%
Havana	11:32 a.m.	12:53 p.m.	2:11 p.m.	53%
Houston	10:33 a.m.	11:27 a.m.	12:22 p.m.	22%
Lima	11:03 a.m.	12:19 p.m.	1:36 p.m.	45%
Managua	9:59 a.m.	11:29 a.m.	1:00 p.m.	76%
Mexico City	9:54 a.m.	11:04 a.m.	12:19 p.m.	42%
Miami	11:43 a.m.	1:01 p.m.	2:15 p.m.	50%
New Orleans	10:41 a.m.	11:41 a.m.	12:41 p.m.	27%
New York City	12:30 p.m.	1:20 p.m.	2:08 p.m.	22%
Pittsburgh	12:25 p.m.	1:09 p.m.	1:53 p.m.	16%
San Juan	11:57 a.m.	1:25 p.m.	2:45 p.m.	90%
Toronto	12:36 p.m.	1:11 p.m.	1:45 p.m.	10%

All times are local time

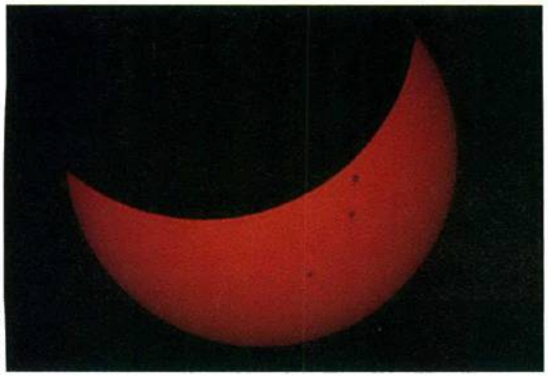
The path of darkness then heads across the waters of the Atlantic Ocean. Approximately 600 miles west of Morocco, the umbral shadow lifts off Earth, not to return until August 1999 when a total eclipse sweeps across Europe and the Middle East. At the same time, the moon's penumbra stretches from Iceland southward across western Africa.

In the United States and Canada, people south and east of a line that curves from Southern California northeastward through Arizona, New Mexico, Kansas, Iowa, Wisconsin, Ontario, and Quebec will see a partial eclipse if skies are clear. Everyone in Mexico and Central America, as well as roughly the northern half of South America, also will see the moon encroach on part of the sun.

Into the Shadow, Lightly

Hundreds of thousands of people will journey into the umbral path to experience the drama of totality. But hundreds of millions more will stay at home on eclipse day to see a partial eclipse of the sun. The odds are you'll be in this latter group. Although your day might not be as dramatic, it can still be memorable.

Those memories won't be pleasant, however, if you don't make an effort to protect your eyes.



Viewed through a filtered telescope, a partial eclipse lets you follow the moon's dark disk as it slowly encroaches on the spotted sun.

Hal Jandorf

Two factors make viewing a partial eclipse extremely dangerous: The eclipse makes you want to look at the sun, and it's easier to gaze at the sun for a long period because the total amount of light coming from it is less.

The human eye acts like a lens, focusing incoming sunlight onto the retina. If you've ever used a magnifying glass to focus sunlight on a piece of paper, you've seen how easily the sun can burn. Well the same thing happens when you look at the sun, except it's the delicate tissue of the retina that burns. Damage can occur in as little as 30 seconds, even with no optical aid. With binoculars or a telescope, the damage happens in a fraction of a second. Because the retina has no pain receptors, there's no warning that anything's wrong, and the visual effects may not show up until hours later.

Fortunately, there are ways to enjoy a partial eclipse without risking your eyesight. The simplest way is to view the sun indirectly by projecting its image. You can make a simple pinhole camera out of two pieces of stiff white cardboard and a piece of aluminum foil. Cut a square hole in one piece of cardboard, then tape the aluminum foil over the hole. Next take a straight pin and poke a small hole in the center of the foil. To view the eclipse, just let the sun's light pass through the pinhole and onto the second piece of cardboard, which serves as a screen.

You can also view a partial eclipse directly if you look through a high-quality filter. An inexpensive filter is a #14 arc-welder's glass, which blocks all the sun's infrared and ultraviolet radiation and slashes visible light by a factor of 370,000. (Make sure to get a #14 glass — those with lower numbers don't filter out enough light.) You can find arc-welder's glass at welding supply stores, listed in the Yellow Pages under "Welding Equipment and Supplies."

Alternatively, you can use either a Mylar filter or a metal-on-glass filter. Mylar filters let more blue light than red light pass through, so they make the sun appear a cool blue-white color. Metal-on-glass filters, on the other hand, yield a yellow-orange sun. Suppliers of these filters can be found in advertisements in *Astronomy*.

Knowing what filters are unsafe is just as important. Never use a "sun filter" that screws on the bottom of a telescope's eyepiece. These filters can crack when in use and let through the full power of the sun's light. Also avoid using exposed color or black-and-white film, sunglasses, smoked glass, polarizing filters, and photographic neutral density filters. Though they limit the amount of visible light that passes through, they do little to stop the equally dangerous infrared radiation.

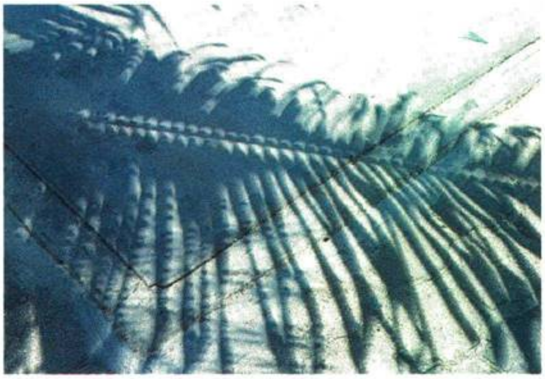
Viewing the Eclipse

What will the properly outfitted eclipse viewer see? For those people near the fringes of the penumbral shadow, about the only detectable effect will be the small bite taken from the sun. Not until the moon covers about half of the sun will a perceptive eye start to notice changes. First, watch for shadows to become sharper as the source of light in the sky becomes smaller.

By the time the moon covers about 80 percent of the sun's disk, the sky has grown noticeably darker and colors seem more vibrant. It's a good time to shift your gaze from the sky to the ground. Look at sunlight filtering through the leaves of nearby trees and bushes (assuming you live in a climate where trees still have leaves in February!) and you'll see hundreds or thousands of tiny images of the crescent sun. The openings between leaves serve as pinholes, each projecting an image of the eclipsed sun.

Certainly the visual treats offered by a partial eclipse are far more subtle than those from a total one, but they are still fascinating examples of what happens when worlds align. And they are far easier to come by. After all, the February eclipse provides totality to only 0.3 percent of Earth's surface, while nearly 20 percent of the globe gets the rewards of a partial eclipse. ■

Richard Talcott (rtalcott@astronomy.com) enjoys viewing both partial and total eclipses, and he plans to be in the path of totality come February 26.


David Beraru

A dramatic and often unexpected eclipse delight is the multitude of miniature eclipsed suns that form under trees and bushes as sunlight passes through their leaves.

The bane of eclipse chasers, the clouds can nevertheless afford a stunning contrast to the bright glare of a partially eclipsed sun.

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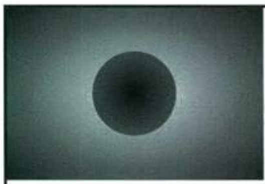

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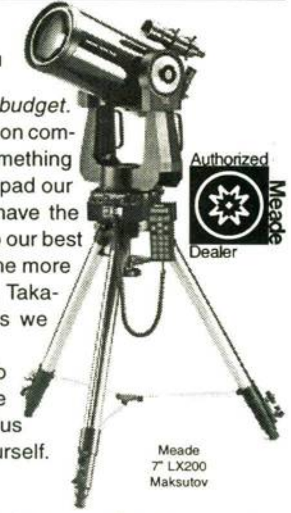

Meade 7" LX200 Maksutov

The right telescope might be an advanced Meade . . .

It doesn't matter whether it's the fully computerized 7" **LX200 Maksutov** above, an 8" or 10" **LX200 Schmidt-Cassegrain**, an 8" or 10" **LX50**, or the hot new 3.5" **ETX Maksutov** to the left (we had 27 in stock at the time this ad was written) – if Meade is shipping it for a dealer to keep in stock, chances are good we *have* it in stock. The same holds true for accessories – like CCD cameras, eyepieces, filters, Barlows, or Magellan computers.

Meade prices are about the same anywhere you call. So why order from a dealer who charges your credit card, then makes you wait until he gets around to ordering what you want? Not when you can get what you want *right now* . . . from ***astronomics.***

Celestron 8" Star Hopper Dobsonian

$499

Get a 10mm eyepiece, 2x Barlow, Telrad finder, and CD-ROM for only $49.95 when you buy this 8" Dob.

The right telescope might be a best-buy Celestron . . .

We sell Celestron's 80mm refractors, 4.5" reflectors, **GP-C102** and **GP-C102ED** 4" refractors, and all 5" to 14" Celestron Schmidt-Cassegrain telescopes. From $299 to $5899, we sell them all.

We have Celestron's $1499 **Pixcel 255** CCD autoguider/imager in stock. It's a *very* user-friendly plug and play CCD camera that will have you taking great CCD images in less than an hour through any SCT. The Pixcel 255 is made exclusively for Celestron by **SBIG**.

We keep Celestron's 6" and 8" **Star Hopper Dobsonians** in stock – technically advanced reflectors that have mirrors with 40% lower thermal mass for faster cooldown time, a unique built-in balance system, no-tool collimation, a free collimating eyepiece, and even more.

If it's a Celestron, we probably have it in stock.

It might be a Takahashi or TeleVue, or the right accessory . . .

Here are just a few of the telescopes and accessories we stock: 3.1", 4", and 5" **Takahashi** ED/fluorite refractors and mounts; the 8.3" **Takahashi CN-212** f/12.4 Cassegrain/f/3.9 Newtonian; the **TeleVue TV-101** and **Genesis** 4" f/5.6 apo refractors; all **TeleVue Pronto** and **Ranger** 2.7" ED refractors; **DayStar** solar filters; **Optec f/3.3 Maxfield** telecompressors and accessories; all **Pentax XL** and **Takahashi** long eye relief eyepieces; both **ScopeSaver** observing tables for your LX200 tripod; **Celestron**, **Edmund**, **Meade**, **Questar**, **TeleVue**, and **Vernonscope** eyepieces & Barlows; **SBIG ST-6A**, **ST-7**, and **ST-8** CCD cameras and the **ST-4** autoguider; all **Lumicon** Deep Sky, UHC, Oxygen III, and H-Beta filters; the **JMI** hard case for the ETX Maksutov-Cassegrain; **Zeiss**, **Leica**, **Bausch & Lomb**, **Nikon**, **Fujinon**, and **Swarovski** binoculars . . . *and much more!*

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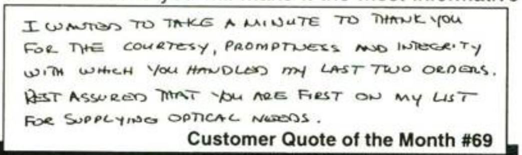
Our free catalog tells how to pick the right Celestron, Meade, Questar, Takahashi, or TeleVue.

Call us at (405) 364-0858, or E-Mail us, for your *free* copy of our catalog 97AST. It covers all the telescopes and accessories we stock – from Celestron, DayStar, Edmund, JMI, Lumicon, Meade, Optec, Pentax, Questar, Rigel Systems, SBIG, Software Bisque, Takahashi, TeleVue, and more. We'll include our 8-page guide on how to pick the right scope and your discount prices on the hundreds of products we carry (sorry, U. S. sales only). The catalog is yours for only the cost of a one minute telephone call. The wealth of detailed information we send you will make it the most informative one minute phone call you will ever invest in astronomy.



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Celestar 8 Deluxe Schmidt-Cass

NEW!

This turbocharged Celestar 8 has a heavier fork mount and a worm-gear drive with PEC. Other enhancements include both R.A. and Dec. motors and hand controller, making it ideal for astrophotography. Also a big 9x50 finder scope, 26mm (78x) Plössl eyepiece (1.25"), star diagonal, equatorial wedge, and heavy-duty aluminum tripod. 2032 f.l., f/10.

CALL

Celestar 8 Deluxe Computerized

NEW!

Same as the Celestar Deluxe but with the Advanced Astro Master computerized pointing system with 10,000-object database. Perfect for the astronomer who wants it all!

CALL

Celestar 8

Celestar 8

Terrific value! Clock-driven 8" f/10 Schmidt-Cass comes complete with high-transmission Starbright coatings, wedgepod, 6x30 finder, star diagonal, and 25mm (81x) SMA eyepiece (1.25").

$1159

Celestar 8 Computerized

$1699

Optional Hand Controller for Celestar 8 $79

Fastar 8 CCD-Optimized Schmidt-Cass

CELESTRON

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Innovative design allows superfast f/1.95 CCD imaging. For use with Celestron PixCel 255 CCD System (sold separately), but also ideal for visual observation at f/10 without the CCD. Fully outfitted.

CALL

PixCel 255 CCD System

Enter the exciting world of CCD imaging. PixCel 255 makes it easy. Includes CCD camera head, CPU box, software, and AC adapter.

CALL

C5+ Schmidt-Cass

CELESTRON

Super-portable and highly versatile, this 5"-aperture *telescope excels* for visual observation and astrophotography. Built-in R.A. drive, equatorial wedge, 6x30 finder, diagonal, and 25mm (50x) eyepiece (1.25"). 1250 f.l., f/10. Tripod optional.

CALL

Field Tripod for C5+	$289
Declination Motor for C5+	$124
Hand Controller	$77
Hard Case	$239

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CELESTRON

Ultima 2000 8"	CALL	**Star Hopper 6" Dob**	CALL
GP-C8	CALL	**Star Hopper 8" Dob**	CALL
Ultima 9-1/4	CALL	**Star Hopper 8" Aluminum**	CALL
Ultima 11	CALL	**GP 102mm EQ Refractor**	CALL
CG 9-1/4	CALL	**Firstscope 60 EQ Deluxe**	CALL
CG 11	CALL	**Firstscope 76 EQ Reflector**	CALL
CG 14	CALL	**Firstscope 80 Altazimuth**	CALL
C4.5 EQ Reflector	CALL	**Firstscope 80 EQ**	CALL
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ORION

NEW!

Argonaut™ 150mm Maksutov-Cassegrain

The design heralded for its extraordinary image quality is now very affordable. Effective focal length is 1800mm (f/12), 150mm (nearly 6") aperture. Includes tube assembly with gearless Crayford 2" focuser, 7x35 achromatic finder, 1/4"-20 plate, and deluxe case.

$999

Argonaut 150 shown with optional star diagonal and eyepiece. Mount sold separately.

Deep Space Explorer™ Dobs

NEW Enhanced Features!

The Dobs *S&T* called a "best buy" are now an even better value! New rack-and-pinion focuser, four-vane secondary mirror support for more precise collimation, larger handle on the Dobsonian base, and black tube finish. Standard accessories include a 25mm Explorer II eyepiece (1.25") and 5x finder scope. Bonus Accessory Package available.

6" (f/8), 8" (f/6), 10" (f/4.5)

From $359

ORION

Premium Deep Space Explorer™ Dobs

The ultimate large-aperture scopes for deep-sky devotees. Hand-figured, diffraction-limited Pyrex optics with enhanced 94%-reflectivity coatings for brighter images. Includes 26mm Sirius Plössl eyepiece (1.25") and choice of focuser.

10" (f/5.6), 12.5" (f/4.8), and 16" (f/4.5) From $799

ShortTube™ 80mm Rich-Field Refractor

ORION

Rich-field 400mm f.l., f/5 scope that's great for observing and prime-focus astrophotography. 6x30 finder, 1.25" rack-and-pinion focuser, 45° erect-image diagonal, and TWO 1.25" Kellner eyepieces. Attaches to any photo tripod or to Orion equatorial mount (sold separately). Optional carrying bag available.

$249

ShortTube 80mm shown on optional equatorial mount.

More Orion Scopes:

ORION

Observer 80mm EQ Ultra Refractor	$319
Observer 60mm Altazimuth	$119
Observer 60mm Altazimuth Ultra	$149
Observer 60mm EQ Refractor	$169
Observer 60mm EQ Ultra	$239
ShortTube 4.5" EQ Reflector	$249
ShortTube 4.5" EQ Ultra	$379
SpaceProbe 3" Altazimuth Reflector	$119
SpaceProbe 4.5" EQ Reflector	$299

Our 22ND year!

Tele Vue

Ranger 70mm Refractor

The highly portable Ranger goes where you go. It combines a 70mm ED-glass achromatic objective and 480mm focal length (f/6.8) with a rugged, all-metal body. Includes helical focuser, mirror diagonal, and 20mm (24x) Plössl eyepiece (1.25").

Green Tube	$649	**Field Flattener**	$99
Brass Tube	$775	**Camera Adapter**	$43.50

More Tele Vue Scopes:

Tele Vue

Tele Vue 101 4" Refractor	CALL
Genesis 4" SDF Fluorite Refractor	CALL
Renaissance 4" SDF Fluorite Refractor	CALL

NEW!

ORION® by Vixen

Shown with optional Sky Sensor 2000.

R200SS GP 200mm Newtonian

The ultimate reflector features big 200mm (7.9") primary mirror in an aluminum tube only 27" long! Short 800mm focal length makes this a super-fast f/4 system, excellent for wide-field viewing and astroimaging. Includes 6x30 finder, 26mm (31x) Sirius Plössl eyepiece (1.25"), precision GP equatorial mount, and aluminum tripod. Optional motor drives, SkySensor "Go To" system, and many other accessories available.

$1499

VC200L GP 200mm Cassegrain

NEW!

Shown with optional Sky Sensor 2000.

Power, portability, and versatility. Outstanding flat-field performance, excels for both visual and imaging applications. Multi-coated 200mm (7.9") primary mirror, 1800mm focal length (f/9.0). Rack-and-pinion focuser prevents image shift that plagues SCTs. No front corrector plate to dew up either! Built-in piggyback mount, 6x30 finder, diagonal, and 26mm (69x) Sirius Plössl eyepiece (1.25"). Includes fantastic GP equatorial mount and aluminum tripod. Motor drives optional.

$1699

VX102 GP Equatorial Refractors

ORION® by Vixen

The Ultimate Dream Refractors!

Manufactured for Orion by Vixen, these 102mm (4") refractors deliver heavenly views of the planets, Moon, and beyond. Impeccable imaging performance. Precision Great Polaris equatorial mount is an engineering masterpiece. Includes 6x30 finder, polar alignment scope, prism diagonal, 26mm Sirius Plössl eyepiece (1.25"), and aluminum tripod. Optional R.A. and Dec. motor drives and hand controllers available.

Standard Model with GP Mount

1000mm f.l., f/9.8	$1199
Tube Assembly Only	$899

Fluorite Model with GP Mount

920mm f.l., f/9.0	$2299
Tube Assembly Only	$1849

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(includes motor drives)	$988

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BINOCULARS

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These high-quality binoculars will provide grand views, offering excellent light-gathering power, moderate magnification, and generous field of view.

Mini Giant binoculars bridge the gap between traditional 50mm "night glasses" and 70mm and 80mm "giant" models. BAK-4 porro prisms, fully multi-coated optics deliver the highest light transmission and contrast. Threaded for tripod mounting.

8x56, 9x63 From $199

Vixen

80mm Binocular Telescope

Looking through TWO premium-quality 80mm (3.1") refractors simultaneously is an unforgettable experience! Uses interchangeable 1.25" telescope eyepieces, allowing wide range of powers! Includes two 25mm eyepieces (36x, 1.1° field). Mount/tripod sold separately.

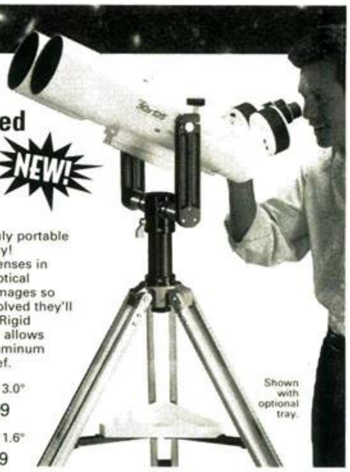
$879

Custom D Altaz Mount/Tripod
Recommended for Vixen BT80.

$433

Vixen

Fork-Mounted 125mm Binocular Telescopes



The most powerful truly portable binoculars you can buy! Whopping 4.9" front lenses in baffled 625mm (f/5) optical system. High-power images so bright, sharp, and resolved they'll knock your socks off! Rigid altazimuth fork mount allows pointing to zenith. Aluminum tripod. 20mm eye relief.

Shown with optional tray.

20x125 Field of view 3.0° $3599

30x125 Field of view 1.6° $3399

CELESTRON

BRIGHT IMAGES!

Ultima® Series

Long 21mm Eye Relief

Scanning the night sky is a treat with these top-quality binos. Fully multi-coated, BAK-4 prisms. Tripod adaptable.

7x50, 10x50, 8x56, 9x63 From $259

CELESTRON

ECONOMICAL!

Pro Series

A popular choice for those who want a better binocular at a reasonable price. Fully multi-coated optics with BAK-4 prisms deliver high contrast and clarity. Water-resistant covering with inlaid grip grooves. Tripod adaptable.

7x50, 10x50, 8x56 From $169

ORION

EXTRA-LONG EYE RELIEF!

UltraView™ 50mm

Best Bino Available For Eyeglass Wearers

Extra-long 22mm eye relief and unique pop-down eyeguards. Fully multi-coated. BAK-4 prisms. Tripod adaptable.

7x50, 10x50 WA $188

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FULLY MULTI-COATED OPTICS!

Vista™ 50mm

Featherlight High-Performance Binoculars

High-index BAK-4 prisms and fully multi-coated optics for high-fidelity images. Soft leatherette covering. Tripod adaptable.

7x50, 10x50 $239

ORION

Big Binocs

All feature the finest fully multi-coated optics and BAK-4 prisms for brightest, sharpest images. All include tripod L-adapter.

Little Giant 10x70	$369
Little Giant 14x70	$369
Giant 11x80	$469
Giant 16x80	$469
Giant 20x80	$469
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FUJINON

Polaris 70mm

Awesome Astro Binos

Flat-field optics reduce distortion and astigmatism to virtually undetectable levels. BAK-4 prisms and EBC multi-coatings. Waterproof, tripod adaptable.

10x70	~~$650~~	CALL
16x70	~~$890~~	CALL

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✧Sirius™

Sirius Plössl Eyepieces

You could pay twice the price for other brands of Plössl eyepieces, but why? Sirius Plössls are top-quality, 50° apparent-field (43° 40mm) eyepieces that yield extremely sharp images of impressively high contrast. Ideal for all types of telescopes. Fully-coated optics, rubber eyeguards. Stock up today!

1.25"

6.3mm, 7.5mm, 10mm, 12.5mm, 17mm, 20mm, 26mm $49.95 each

32mm, 40mm $59.95 each

.965"

6.3mm, 7.5mm, 10mm, 12.5mm, 17mm, 20mm, 26mm $49.95 each

ORION

Ultrascopic Eyepieces

The highest contrast and light transmission obtainable. Superior 5- or 7-element design with Ultra Multi-Coatings™ on every surface. Wide 52° apparent field. Removable winged rubber eyeguard. Threaded for filters. 1.25" barrels.

3.8mm, 5mm, 7.5mm, 10mm, 15mm, 20mm, 25mm, 30mm, 35mm From $79

ORION

Explorer II Eyepieces

Attractively priced for even limited budgets. Their 3- and 4-element fully coated glass lens configurations provide a 50° apparent field of view. Threaded for filters.

.965"

6mm, 10mm, 13mm, 17mm, 25mm $29.95 each

1.25"

6mm, 10mm, 13mm, 17mm, 25mm $34.95 each

Illuminated Reticles, wireless

12mm Kellner	$99
12.5mm Plössl	$139
9mm Orthoscopic	$159

CELESTRON

Ultima Series Eyepieces

Fully multi-coated Ultima 1.25" eyepieces feature 4 to 7 lens elements with blackened edges. All are threaded for filters, have rubber grip rings and rubber eyecups.

5mm, 7.5mm, 12.5mm, 18mm, 24mm, 30mm, 35mm, 42mm	From $83
6.5mm–18mm Zoom (1.25")	$169
Micro Guide Illuminated Reticle	$189
Pulstar Reticle Blinker	$69

Vixen Lanthanum Eyepieces

Long 20mm eye relief makes them ideal for eyeglass wearers. Apparent field 50° (9mm-15mm) or 45° (2.5mm-6mm). 1.25" barrels.2.5mm, 4mm, 5mm, 6mm, 9mm, 10mm, 12mm, 15mm, 8-24mm zoom From $134

PENTAX

SALE!

SMC XL Series Eyepieces

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5.2mm, 7mm, 10.5mm, 14mm, 21mm, 28mm, 40mm From $249

Barlow Lenses

Celestron Ultima 2x (1.25")
Tele Vue 2x (1.25")
Tele Vue 3x (1.25")
Tele Vue Big Barlow (2")
Orion Deluxe 2x (.965", 1.25", 2")
Orion Shorty (.965", 1.25")
Orion VariPower 2x–3x (1.25")

From $39.95

Tele Vue

NEW!

24mm-8mm Zoom Eyepiece

Multi-coated, 40°-50° apparent field, 15-20mm eye relief. 1.25" barrel. $219

Plössl Eyepieces

Fully multi-coated, 50° apparent field (43° for 40mm). All have 1.25" barrels except 55mm (2").

8mm, 11mm, 15mm, 20mm, 25mm, 32mm, 40mm, 55mm From $89

Panoptic Eyepieces

Six-element oculars with wide apparent field of 68° and long eye relief. Multi-coatings.

15mm (1.25"), 19mm (1.25"), 22mm (1.25"/2"), 27mm (2"), 35mm (2") From $224

Nagler/Nagler 2 Eyepieces

Dramatic 82° apparent field with full-field correction for pinpoint images edge to edge.

4.8mm (1.25"), 7mm (1.25"), 9mm (1.25"/2"), 12mm (1.25"/2"), 13mm (1.25"/2"), 16mm (1.25"/2"), 20mm (2") From $189

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Spend your time viewing celestial objects instead of hunting for them! Sky Wizard tells you right where to point your scope. Incredibly easy to use and works with any telescope, equatorial or altazimuth. Requires installation kit, sold separately.

Sky Wizard Model 1	$189
Sky Wizard Model 2	$259
Sky Wizard Model 3	$369

Collimating Eyepiece

Combination Cheshire eyepiece and sight tube. Essential for optimizing performance of fast Newtonians.

$34.95

Filters

Lunar (.965", 1.25")	$15.95
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Many different sizes in stock. From $59.95

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Dual-Ring Bracket for 8x50	$34.95

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NEW!

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Celestron f/6.3 Reducer-Corrector

CALL

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AccuTrack DC Motor Drive for SkyView Equatorial Mount	$89
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Vixen GP R.A./Dec. Motor	$99
Vixen Single-Axis Controller	$119
Vixen Dual-Axis Controller	$199

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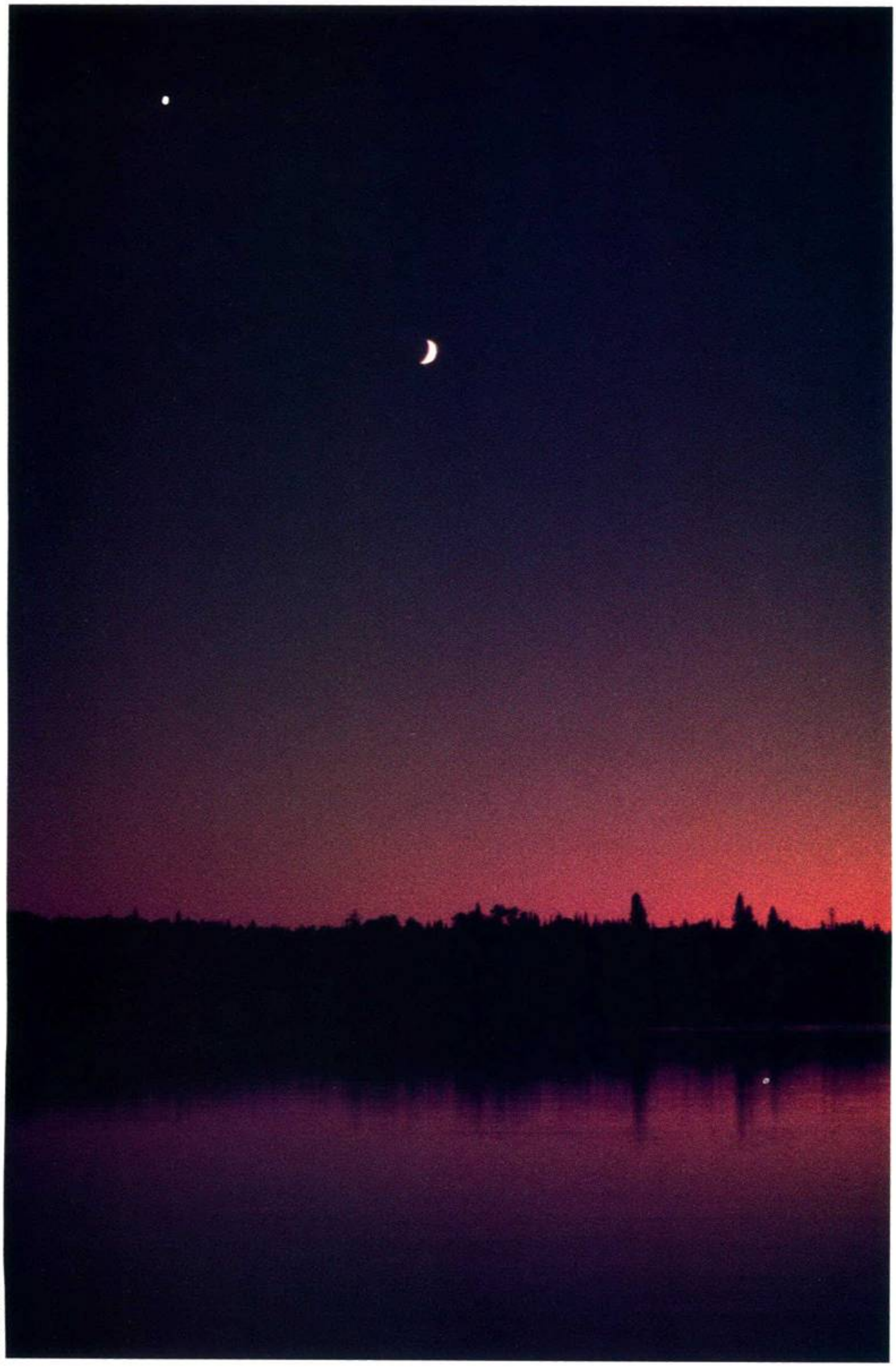
THE SKY SHOW

November's skies give cause for thanksgiving. Jupiter takes center stage as it occults SAO 164156, and its moons put on a spectacular triple transit show. Venus and Mars are in conjunction, and Uranus and Neptune bid us farewell until next year. By Martin Ratcliffe and Alister Ling



Jon Schufman

Five planets were known to ancient humanity: Mercury, Venus, Mars, Jupiter, and Saturn. Four of these five "wandering stars" will display their scintillating luminance in November's evening twilight, giving us the chance to relive the awe experienced by our ancient ancestors.

Mercury lives up to its reputation as the elusive planet. Making a brief evening appearance late in November, it hugs the southwestern horizon — typical of a planet that never ventures far from the sun in angular separation. Because Mercury lies south of the celestial equator, this elongation is best observed from the Southern Hemisphere.

The most brilliant of all the planets, **Venus** shines at magnitude –4.5 and reaches its greatest elongation to the east of the sun, standing 47.1° away on November 6. A few days before elongation, Venus reaches "dichotomy," the point at which the planet's disk appears precisely half-lit. Observers with small scopes can see it gradually approach over the course of several nights as the shape of the terminator changes from slightly convex to perfectly straight and eventually to concave. Venus also reached

Here Venus watches the moon set over Lake Poplar, Minnesota. November's skies give lots of opportunities to glimpse celestial bodies together in the sky. Look for the triple transit of Jupiter's moons, the occultation of a 6th-magnitude star, and two planets in conjunction.

NOVEMBER 1997

1 Asteroid Leto is at opposition, 3 p.m. EST

3 The moon passes 6° north of Mars, midnight EST

4 The moon passes 9° north of Venus, 6 a.m. EST

6 Venus is at greatest eastern elongation (47°), 2 a.m. EST
The moon passes 4° north of Neptune, 10 a.m. EST
Asteroid Fides is at opposition, 10 p.m. EST
The moon passes 4° north of Uranus, midnight EST

7 The moon passes 4° north of Jupiter, 3 p.m. EST
First quarter moon is at 4:43 p.m. EST

11 The moon passes 0.4° north of Saturn, 8 p.m. EST (page 73)

12 The moon is at perigee (225,794 miles from Earth), 2:56 a.m. EST

13 Mercury passes 2° north of Antares, 11 p.m. EST

14 Full moon is at 9:12 a.m. EST

15 The moon passes 0.5° north of Aldebaran, 3 p.m. EST

16 Asteroid Metis is at opposition, 9 a.m. EST

17 Leonid meteor shower peaks (page 71)

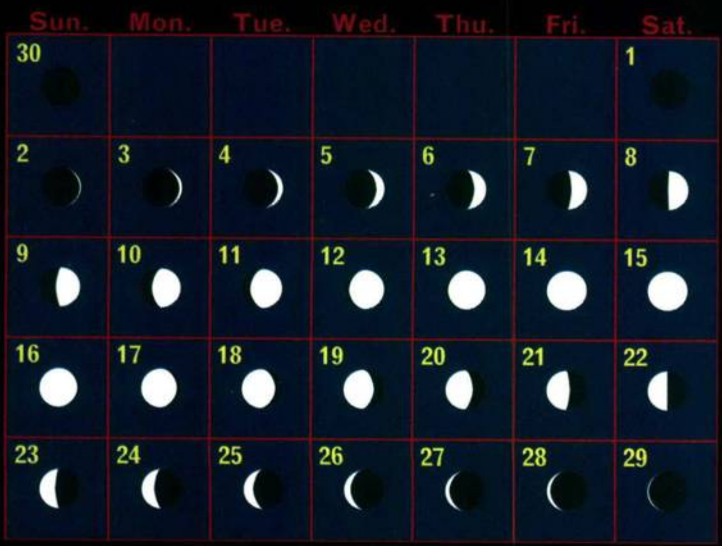
21 Asteroid Julia is at opposition, 4 a.m. EST
Last quarter moon is at 6:58 p.m. EST

23 The moon is at apogee (251,466 miles from Earth), 9:28 p.m. EST

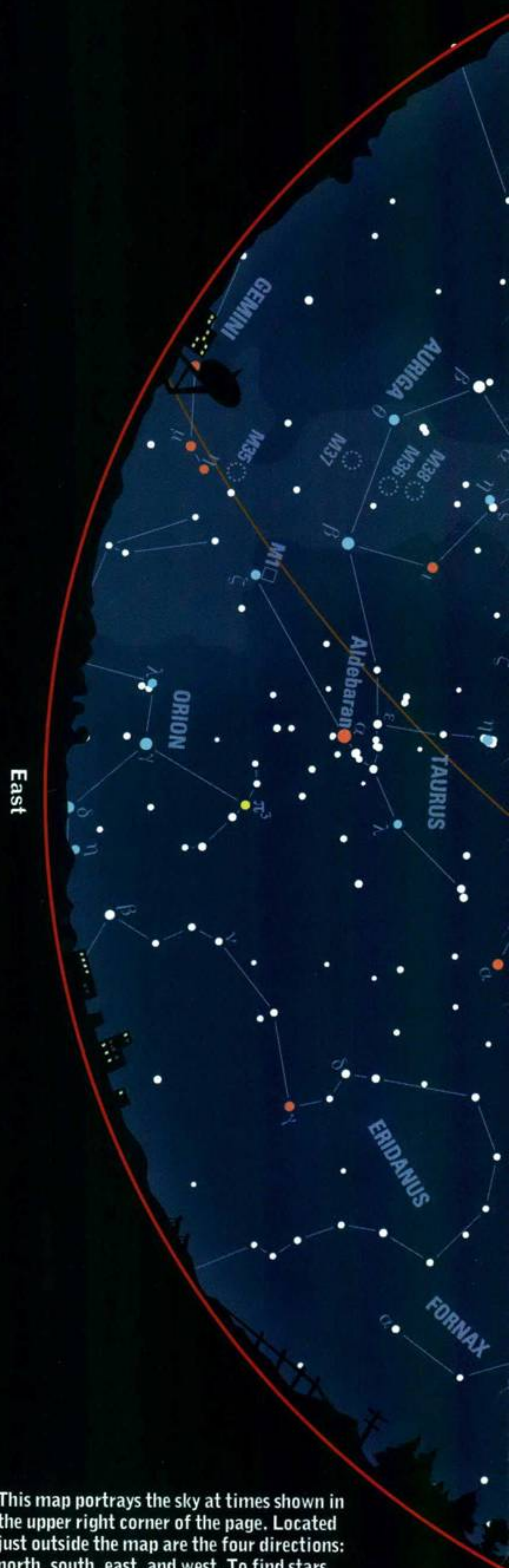
27 Pluto is in conjunction with the sun, noon EST

28 Mercury is at greatest eastern elongation (22°), 11 a.m. EST

29 New moon is at 9:14 p.m. EST



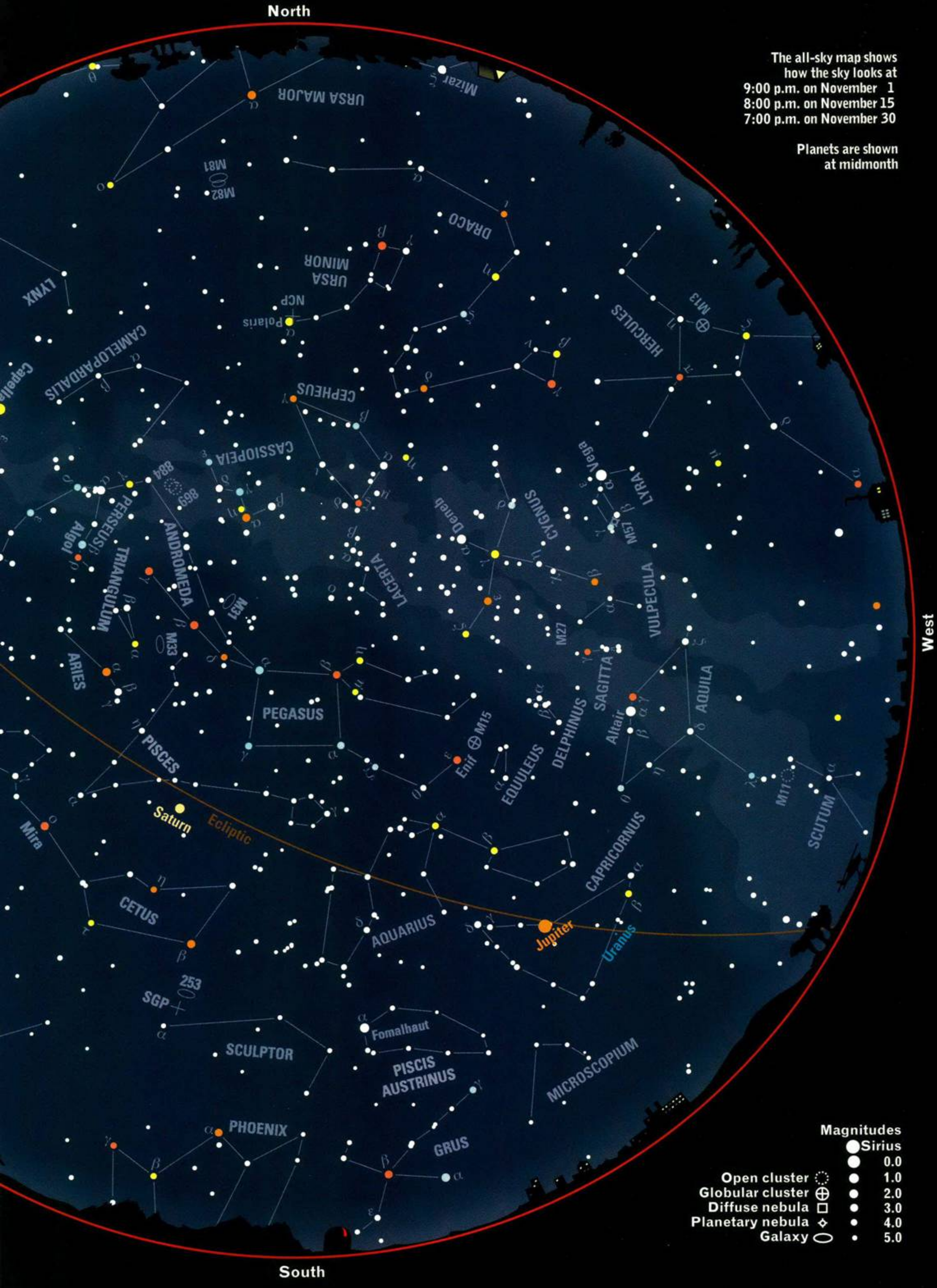
Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
30						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29



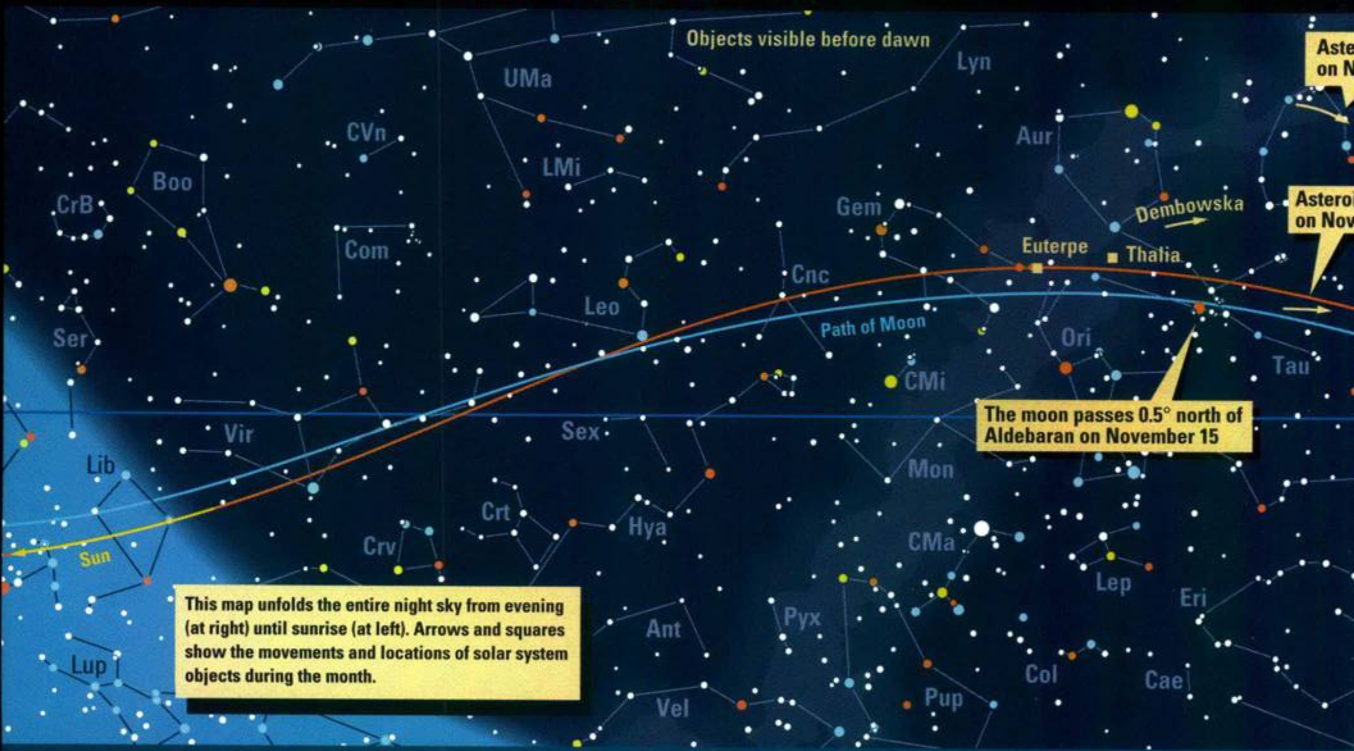
This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

The all-sky map shows
how the sky looks at
9:00 p.m. on November 1
8:00 p.m. on November 15
7:00 p.m. on November 30

Planets are shown
at midmonth

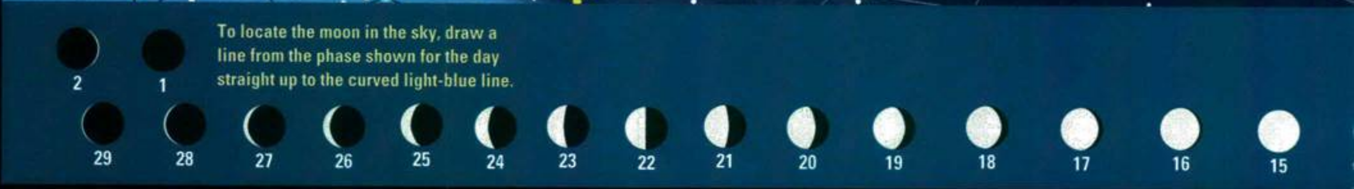

North
South
West
URSA MAJOR
Mizar
M81
M82
DRACO
URSA MINOR
NCP
Polaris
LYNX
CAMELOPARDALIS
Capella
CEPHEUS
HERCULES
M13
CASSIOPEIA
884
869
PERSEUS
Algol
TRIANGULUM
ANDROMEDA
M31
M33
ARIES
LACERTA
Deneb
CYGNUS
Vega
LYRA
M57
VULPECULA
M27
SAGITTA
AQUILA
Altair
DELPHINUS
EQUULEUS
Enif
M15
PEGASUS
PISCES
Saturn
Ecliptic
Mira
M11
SCUTUM
CAPRICORNUS
Jupiter
Uranus
AQUARIUS
CETUS
253
SGP
SCULPTOR
Fomalhaut
PISCIS AUSTRINUS
MICROSCOPIUM
PHOENIX
GRUS
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

THE PATH OF THE PLANETS


Objects visible before dawn
UMa
Lyn
CVn
LMi
Aur
Boo
CrB
Gem
Com
Dembowska
Euterpe
Thalia
Cnc
Leo
Path of Moon
Ser
Ori
Tau
CMi
Vir
Sex
Lib
Mon
Crt
Hya
CMa
Sun
Crv
Lep
Eri
Ant
Pyx
Lup
Col
Cae
Vel
Pup
Aste
on N
Asteroi
on Nov

The moon passes 0.5° north of Aldebaran on November 15

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.


2
1
29
28
27
26
25
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19
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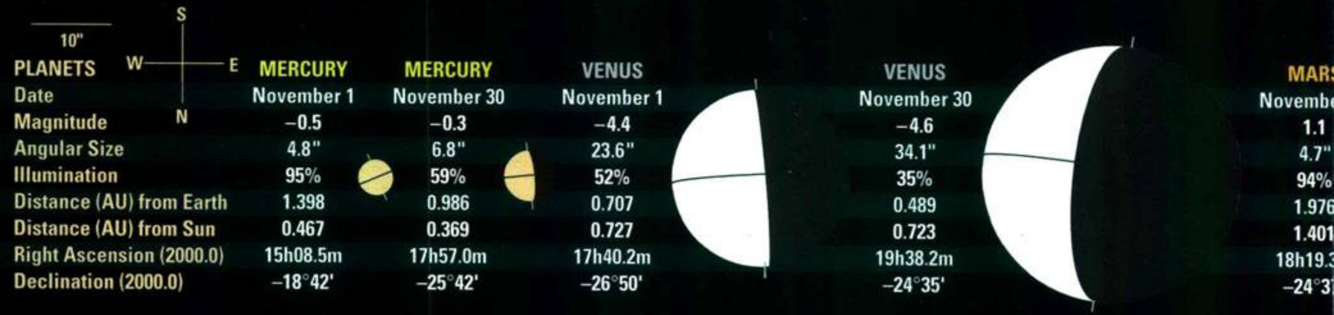
17
16
15

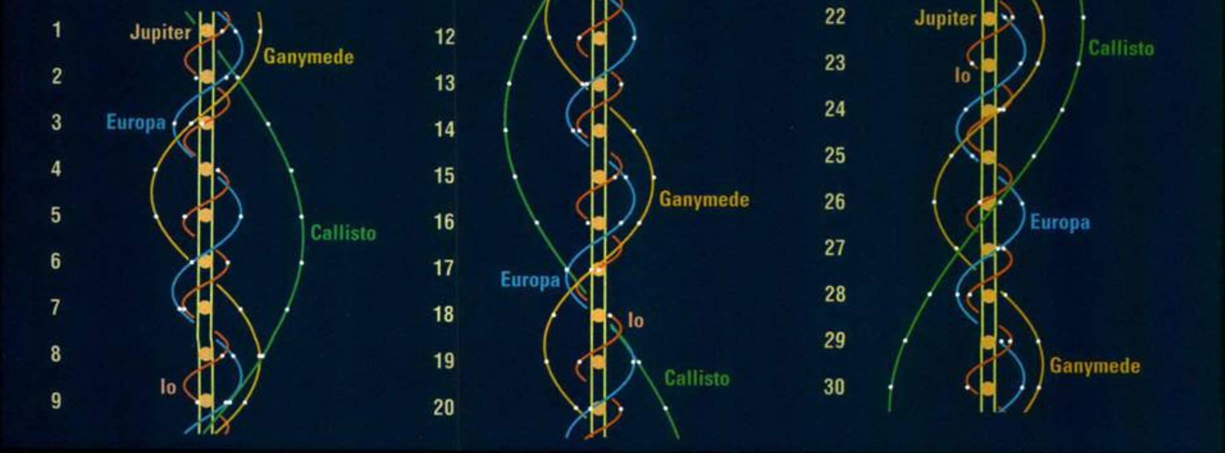
To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

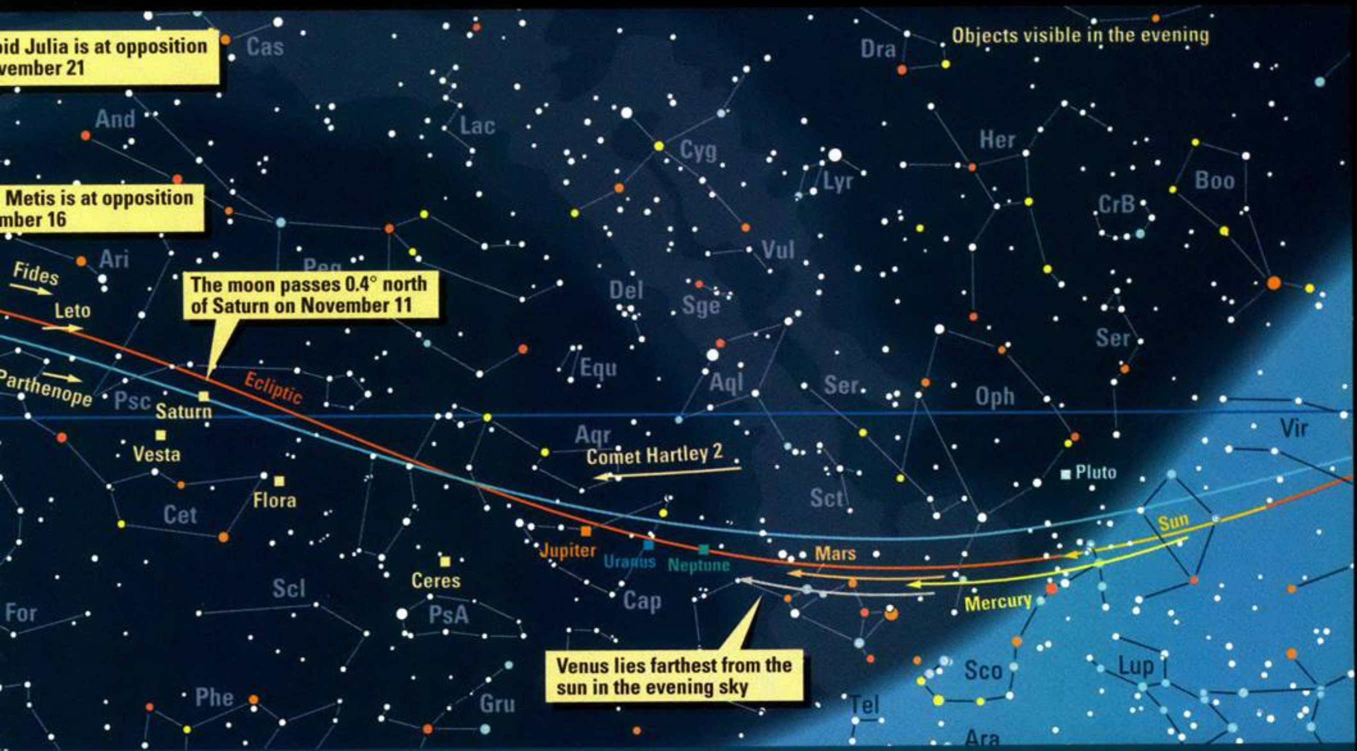


PLANETS	MERCURY	MERCURY	VENUS	VENUS	MARS
Date	November 1	November 30	November 1	November 30	Novembe
Magnitude	–0.5	–0.3	–4.4	–4.6	1.1
Angular Size	4.8"	6.8"	23.6"	34.1"	4.7"
Illumination	95%	59%	52%	35%	94%
Distance (AU) from Earth	1.398	0.986	0.707	0.489	1.976
Distance (AU) from Sun	0.467	0.369	0.727	0.723	1.401
Right Ascension (2000.0)	15h08.5m	17h57.0m	17h40.2m	19h38.2m	18h19.3
Declination (2000.0)	–18°42'	–25°42'	–26°50'	–24°35'	–24°3

JUPITER'S MOONS

Dots display positions of Galilean satellites at 10 p.m. EST on date shown. South is at top to match the view in a telescope.




Cas
And
Lac
Cyg
Lyr
Dra
Her
Boo
CrB
Ari
Peg
Vul
Del
Sge
Equ
Aql
Ser
Oph
Ser
Vir
Fides
Leto
Parthenope
Psc
Saturn
Ecliptic
Vesta
Flora
Cet
Aqr
Comet Hartley 2
Sct
Pluto
Sun
Jupiter
Uranus
Neptune
Mars
Mercury
Cap
Ceres
Scl
For
PsA
Phe
Gru
Tel
Sco
Lup
Ara

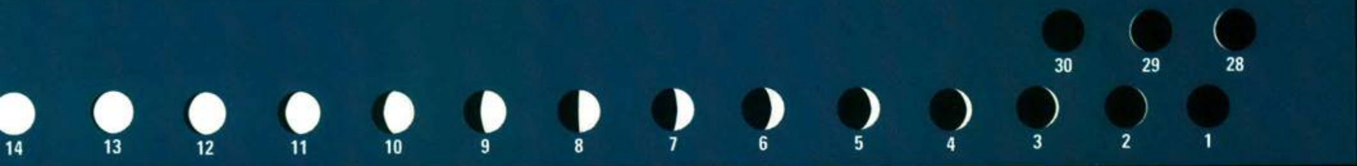
oid Julia is at opposition
vember 21

Metis is at opposition
mber 16

The moon passes 0.4° north of Saturn on November 11

Venus lies farthest from the sun in the evening sky

Objects visible in the evening


30
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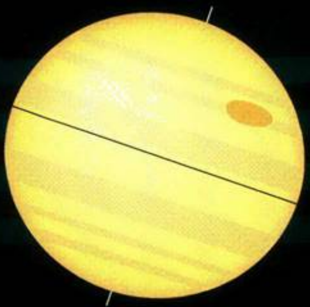
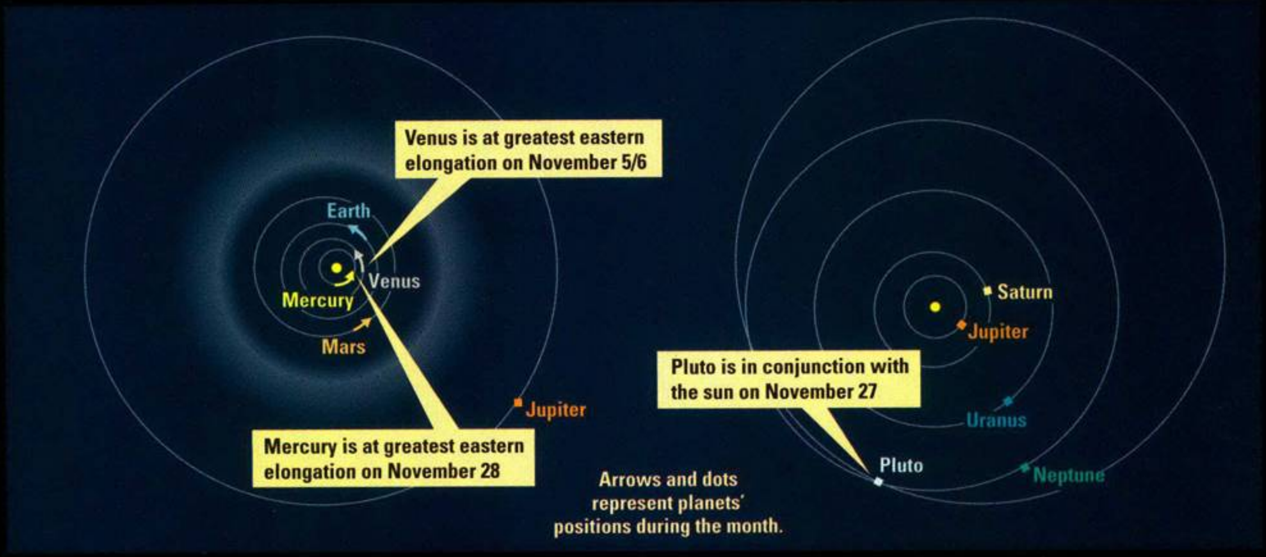
1



	JUPITER	**SATURN**	**URANUS**	**NEPTUNE**	**PLUTO**
r 15	November 15	November 15	November 15	November 15	November 15
	–2.3	0.4	5.8	8.0	13.8
	38.8"	19.4"	3.5"	2.2"	0.1"
	99%	100%	100%	100%	100%
	5.080	8.584	20.113	30.553	30.963
	5.034	9.380	19.838	30.147	30.019
m	21h08.6m	0h57.3m	20h30.8m	19h58.3m	16h20.9m
	–17°23'	3°12'	–19°34'	–20°16'	–9°25'

THE PLANETS IN THEIR ORBITS


Earth
Venus
Mercury
Mars
Jupiter
Saturn
Jupiter
Uranus
Pluto
Neptune

Venus is at greatest eastern elongation on November 5/6

Mercury is at greatest eastern elongation on November 28

Pluto is in conjunction with the sun on November 27

Arrows and dots represent planets' positions during the month.

FIRST VIEWS: The Quaint M72 and M73

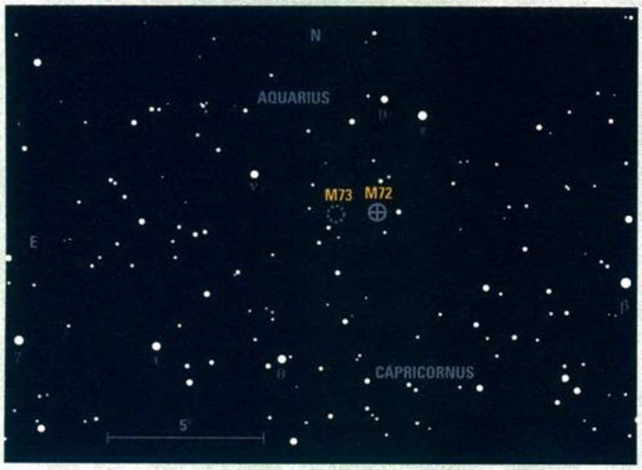
Most well-known deep-sky objects are described with superlatives, but this wide pair is in a class by itself. M72 is a distant globular cluster, while M73 is classed as an asterism, simply a group of four bright stars.

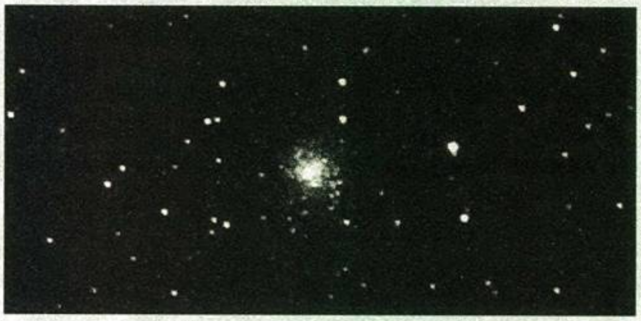
It's the easiest starhop ever — Jupiter points the way, lying only one binocular field south of this Laurel and Hardy pair.

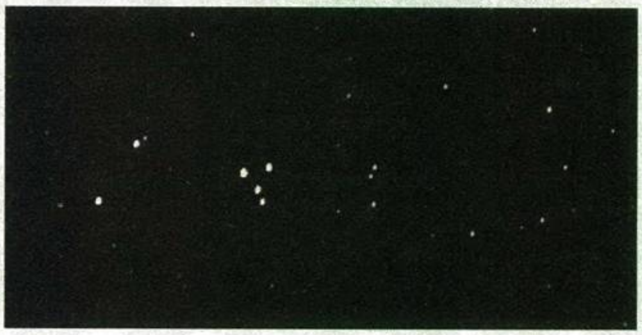
Tucked away among the rich but faint starfields of western Aquarius, M72 shows up in a low-power rich-field telescope as a little fuzzy cotton ball of 9.4 magnitude. A 6-inch scope at high power from a country sky will pick up a few of the cluster's red giants, giving the object an overall granulated appearance.

The Laurel of the pair is M73, one degree farther east, at times dissolving into the background starfield. It is made up of four stars in a roughly triangular shape, all 10th- to 12th-magnitude. The comet hunter Charles Messier described it as "a cluster of three or four small stars which resembles a nebula at first sight, containing a little nebulosity." Today's superior optics show no trace of nebulosity at all, but the thin clump is quaint.

Don't forget to take the opportunity to compare M72 with Comet P/Hartley 2 at the end of the month.




Thomas L. Dessert


Thomas L. Dessert

its farthest distance south of the celestial equator late last month, so it will remain low in the southwest.

With so many background stars, it's inevitable that planets will pass near them. Nonetheless, a planet passing close to a fairly bright star is always striking. One such occasion occurs on November 18, when Venus passes less than six arcminutes south of the magnitude 2.0 star Sigma (σ) Sagittarii — grab a pair of binoculars to catch a glimpse of this close conjunction.

What could be better than seeing a star and planet in conjunction? How about two planets at once. Look across the solar system behind Venus, along the same line of sight, to find the fading globe of **Mars**, now at magnitude 1.1. Venus and Mars will separate slowly with each passing night, so look early in the month. An added bonus, the fine crescent moon joining the coupling on November 3 and 4, provides a wonderful opportunity for creative photography. Set up a camera and tripod and fire off a dozen exposures of various lengths, ranging from one to ten seconds. A well chosen foreground feature such as a tree or building will appear in stark silhouette against the deepening twilight.

By November 7, the first quarter moon has pulled up alongside **Jupiter**. When darkness falls, Jupiter is well situated for early evening viewing, positioned in the southern part of the evening sky. The brilliant magnitude –2.4 planet wanders south of Theta (θ) Capricorni and reaches east quadrature, the point at which the Jupiter-sun-Earth angle is precisely 90°, on November 5.

Viewed up close through a telescope, Jupiter is a fine object. A scope will reveal delicate dark bands across the equatorial regions, making them easy to see at first glance. But don't turn away yet. Wait a while, and look patiently — brief periods of momentary stillness in the atmosphere can provide glimpses of tremendous detail: more bands, black spots, white spots, whirls, and festoons in the turbulent atmosphere.

Also of interest are Jupiter's bright moons, which would be easily visible to the naked eye if they weren't overpowered by the brilliant planet. Two unusual events occur this month, adding to the wonder of watching their oscillating motions back and forth around the planet. On November 10, a rare triple shadow transit occurs. The shadows of three moons, Callisto, Ganymede, and then Io, each fall onto the body of Jupiter over a 90-minute period, beginning at 9:10 p.m. EST. All three can be seen on the planet after 10:34 p.m. EST, just 30 minutes before Jupiter sets on the east coast and well placed for viewing from the United States (see box for details).

In addition to the rare shadow transits, Jupiter occults SAO 164156, a 6th-magnitude star in the constellation Capricornus, on November 12. Watch this fascinating event as Jupiter appears, temporarily, to have an extra moon. Notice the difference between the star and the moons through a scope — the moons are tiny disks, but because it's so far from us, the star is a pinpoint of light.

Don't miss your last glimpse of **Uranus** and **Neptune** this year, in the same area of the sky as Jupiter. Uranus is the easier target, being brighter at magnitude 5.8, and lying a degree south of Pi (π) Capricorni. Shining at magnitude 8, Neptune is harder to spot in the sparse region of eastern Sagittarius.

Once the early evening has gone by, turn your attention farther east to find **Saturn**, lying in dim Pisces and glowing brightly high in the south by 10 p.m. The ringed planet outshines all the stars in this region of the late fall sky.

The top event of the month is the occultation of Saturn by the moon on November 11, visible across the southeastern United States. Locations south of a line stretching from Boston, Massachusetts, to Houston, Texas, will be privy to this celestial event.

Spectacular Shadows and Shields

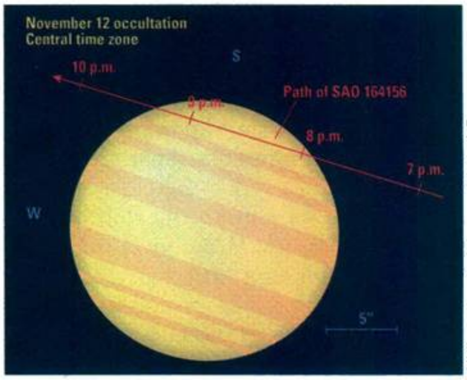
By Jove, what a month for Jupiter! It occults a 6th-magnitude star, provides the backdrop to the frenetic multi-shadow play of the Galilean moons onto the cloud decks below, and hosts the eclipse and occultation satellite series.

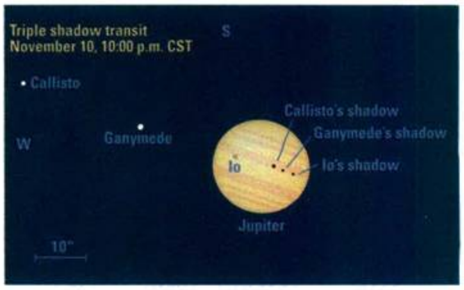
Reserve Monday the 10th for a rare show — three moons cast their shadows on Jupiter at once. For an amazing two hours and 17 minutes the inky black shadow dots of Io, Ganymede, and Callisto will drift across the cloud-strewn disk. Two shadows will hang around for 3.5 hours, starting at 9:10 p.m. EST (6:10 p.m. PST). Unfortunately for easterners, Jupiter sets at 10:25 p.m. EST, ten minutes before the third shadow hits the scene.

Try to spot the fleet-footed pale disk of Io running ahead. If you can't, wait until 8:23 p.m. PST (9:23 p.m. MST).

Ganymede will cast its shadow on Io, darkening it against the cloudtops and making a light gray shadow. Ten minutes later, Io leaves Jupiter's edge to remain partially eclipsed for twelve minutes more.

Because Jupiter's equator lies edge-on as viewed from Earth, the moons also block and shadow each other.

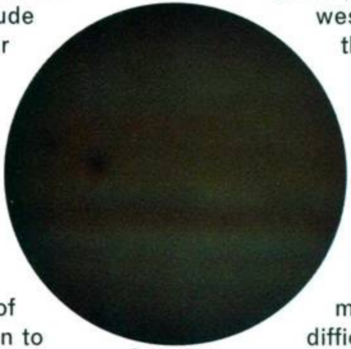




All illustrations by *Astronomy*: Elisabeth Rowan

Clear all earthbound commitments on the evening of the 12th. Jupiter slides in front of 6th-magnitude SAO 164156. Watch the star flicker as it disappears and reappears from behind the layers in the gas giant's upper atmosphere. You're lucky to witness a show like this once in ten years, factoring weather and location into the equation.

Those who live northeast of a line stretching from Boston to Montreal suffer a sad fate. They don't have tickets to the show because Jupiter and the star set in these locations just as the action begins, at about 10:20 p.m. EST (7:20 p.m. PST). The farther west you are, the higher in the sky Jupiter will be, and hence the better the viewing conditions. Use the diagram at top to estimate the time for your geographic site. Unfortunately, low altitude combines with little advance notice, making the reappearance difficult to observe.



Stephen Keene

The top four events for North America are listed below. A complete listing of the mutual activity visible from any place on Earth can be found at http://www.bdl.fr/phenum97_eng.html.

Date	Event	Type of Event	Begins (EST)	Ends (EST)	Light Loss	Distance (Jupiter radii)
Nov. 2	Ganymede occults Callisto	Partial	10:37 p.m.	10:47 p.m.	41%	8.1
Nov. 6	Europa occults Ganymede	Partial	10:05 p.m.	10:11 p.m.	20%	3.3
Nov. 10	Ganymede eclipses Io	Partial	11:25 p.m.	11:44 p.m.	88%	1.0
Nov. 17	Ganymede eclipses Io	Partial	9:03 p.m.	9:31 p.m.	44%	2.6

Please share your experiences of these events with *Astronomy*.

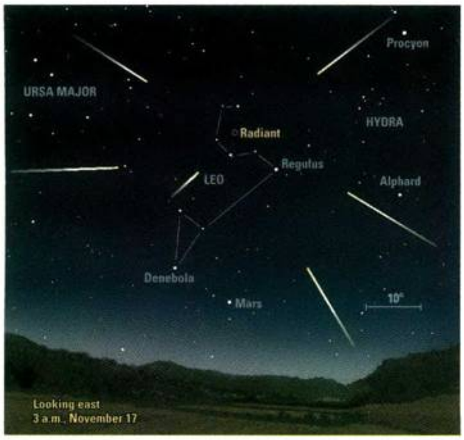
Thanksgiving's Leonid Meteors

Meteor observers have good reasons to give thanks for the Leonids this year. Despite a near-full moon lighting up the sky, the Leonids have shown increased counts as they approach a possible mini-storm in 1998.

This type of burst happens every 33 years as the shower's parent comet, Tempel-Tuttle, passes through the inner solar system. Next February the comet is expected to reach its closest approach to the sun.

Meteors occur when comet dust burns up in Earth's atmosphere. The closer we are to a comet's path the more debris we are likely to receive.

Frank Zullo



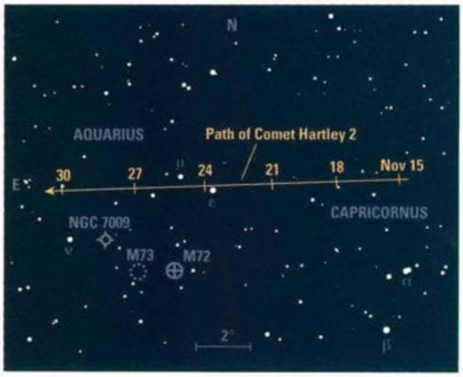
This year the peak of activity blesses North Americans, occurring at 6 a.m. EST on the morning of the 17th. Will it be strong? It's difficult to estimate the rate due to the positive increase in arrivals and the negative effect of moonlight. Still, we may see a shower rivaling the Perseids in productivity, that is some 50–100 meteors per hour. Even factoring in moonlight, country skies are better than city ones.

The best seats open up after midnight when the source of the Leonids, in the Sickle of Leo, rises high in the sky. Arm yourself with a lawn chair, sleeping bag, hot drinks, and good company. Don't forget to bring binoculars to watch long lasting comet trails twist in the upper atmospheric winds.

Periodic Comet Hartley 2 Glides in for a Visit

No short-term periodic comet in our lifetimes will match Hale-Bopp, but P/Hartley 2 is worth following if only to hone your observing skills for the next big one and see what a typical backyard comet looks like.

This will be its third 6.4-year orbit since Malcolm Hartley discovered it in 1986. P/Hartley 2 will be brightest when it reaches its close approach to the sun on the winter solstice. As it closes in on Earth this month, it should hit 10th magnitude, making it the same in terms of brightness as many deep-sky objects.



On the evenings of the 7th through the 9th, you will be able to compare the comet in size, brightness, and form to NGC 6814, an 11th-magnitude galaxy only one degree to the south. By the time the moon leaves the evening sky, P/Hartley 2 will be closing to within 5° of the interesting objects M72, M73, and the Saturn Nebula, NGC 7009.

Observers stationed along this line will experience a grazing occultation, where only part of Saturn and its rings will be hidden by the limb of the moon. Events like these are rare and well worth making the effort to view — you will see nothing else quite like it, and the event promises to provide lifelong memories.

The appearance of the rings through any telescope shows that they have closed a little over the past few months. Saturn reached its brightest last month and fades to magnitude 0.5 by the end of November. Though dimmer than before, Saturn's brightness even now outshines one of the Summer Triangle's stars, Deneb in Cygnus, now descending in the west along with Vega and Altair, resident stars within the constellations of Lyra and Aquila respectively.

The constellation of Pisces the Fish, in which Saturn now currently lies, contains no stars brighter than 4th magnitude. Two lines of faint stars are said to represent two fish swimming in opposite directions with their tails tied together. According to Greek myth, Mother Earth, also known as Gaia, produced as offspring Typhon, a multi-headed beast who spat tongues of fire. Aphrodite and her son Eros hid among the reeds of the river in order to escape Typhon's terror.

One tradition tells of two fishes swimming alongside them and carrying them to safety. Another indicates that the pair themselves turned into fish.

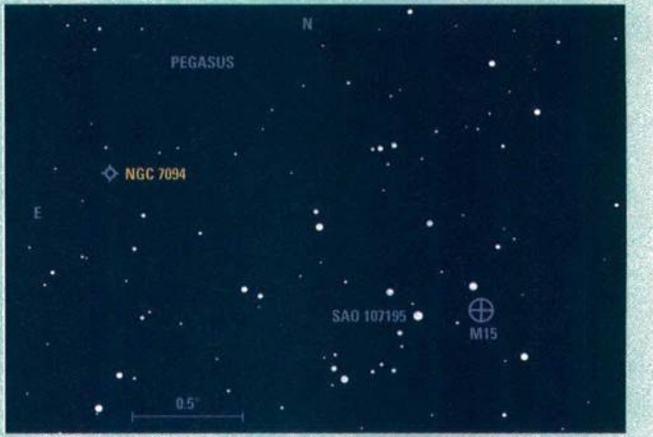
The "Hollywood fantasy movies" of ancient times, these tales were lively and full of drama and carried messages for the ages in

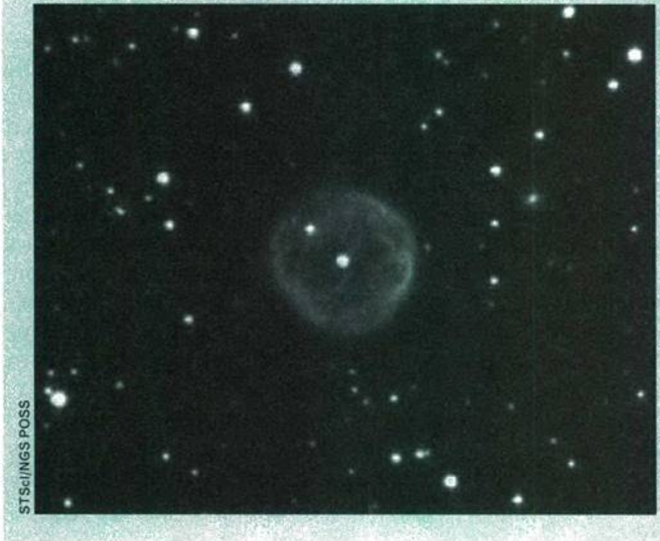
OBSERVER'S CHALLENGE: NGC 7094, a Pegasus Planetary

Pegasus is well known for its galaxies and clusters of galaxies, from the barred spiral NGC 7479 to Stephan's Quintet — there's precious little else of note. Ah, but precious are the planetary nebulae this constellation does offer.

Arguably the most famous puff ball of gas from a dying star in Pegasus is Jones 1, a large ghostly glow. Oddly enough, it overshadows our challenge object, NGC 7094, which is in fact easier to see than Jones 1.

A 10-inch scope in average country skies can ferret out this 95-arcsecond planetary, but it requires some patience. It may be a bit bigger than M57, the Ring Nebula, but NGC 7094's total light output is less, so its surface brightness is quite low. At low power, the skyglow pulled in by the scope overpowers the pale disk. A high contrast nebular filter solves that problem.




STScI/NGS POSS

To get a better look, shift to higher powers, say 180x – 250x. The sky darkens and the image is magnified up to a size from which your eye can pick out details — a "win-win" situation. A faint, mostly uniform halo surrounds a magnitude 13.5 central star. The slightly brighter north and south edges adorn the nebula.

Don't feel too bad if NGC 7094 eludes you — the great visual observers William and John Herschel never saw it — leaving it for Lewis Swift to discover.

In the sky, NGC 7094 is fairly easy to find. It's located at 21h36.9m +12°47' (2000), just a 1.5° skip away from the bright globular cluster M15.

which they were developed. The fables varied from culture to culture.

Pisces also claims a special point in our coordinate system — a point where the sun crosses the celestial equator while moving into the Northern Hemisphere — known as the spring, or vernal equinox. This point is also called the First Point of Aries and is the zero point for measurement of right ascension, the "longitude" scale of the sky. Since it has drifted into Pisces, it should really be called the First Point of Pisces, but historical continuity maintains the traditional phrase. The point drifts due to precession, the phenomenon than causes Earth to wobble on its axis like a spinning top. One wobble takes 25,800 years and changes the pole star over the centuries.

The Andromeda Galaxy (M31) passes high overhead as Saturn lies due south. To its northeast you'll find the Double Cluster (NGC 869 and NGC 884) nestled in Perseus. Already rising in the east by late evening are the stars of winter, led by Taurus the Bull and eagerly tracked by Orion the Hunter. The full moon occurs on November 14 and can be found just west of the Hyades star cluster in Taurus. The November full moon is sometimes called the Frosty Moon or Beaver Moon, since beavers, as well as stargazers, notice upon its arrival that winter is on the way and that preparations need to be made.

In a relaxed repose, Gemini the Twins rise gently over the eastern horizon. If you can wait a couple hours more, spend your time wandering through the star clusters and nebulae of Orion, Taurus, and Gemini. Notice the Milky Way neatly dividing the northern and southern halves of the sky as it moves overhead from east to west. Before you know it, the head of Leo the Lion will peer over the eastern horizon and with it, a growing and developing meteor shower, which appears to radiate from that direction in space.

The Leonid meteor shower is associated with Comet P/Tempel-Tuttle, due to reach perihelion next year. Counts of meteors have been rising steadily over the past few years, and anticipation is building for the expected storm of shooting stars in 1998. The last storm occurred in 1966, and storms are expected, though not always observed, about every 33 years. This year a bright moon interferes with the peak of activity on November 17, but keep watch. Rates could be anywhere from 30 to 100 per hour, although the moonlight will have a marked effect on their observability.

November 30 offers an opportunity for east coast observers to see a very young moon. Ideal atmospheric conditions must combine with a clear western horizon to make catching a glimpse of the moon so soon after new even remotely possible. The thin sliver of the new crescent moon sets almost an hour after the sun.

Really young moons are a breathtaking sight — the thinnest of silver crescents lying against a dramatic deepening orange glow. Few people have seen a crescent moon less than 24 hours old, but on the evening of the 30th, those on the east coast will get a chance to see one only 19.4 hours after its conjunction with the sun. The moon ages an hour or so for each time zone farther west.

Start about half an hour after sunset and scan five degrees above the horizon, about a binocular field high. Unless you are eagle-eyed, you'll be better off first finding the crescent in binoculars. Make sure you have access to a decent horizon, unfettered by trees or buildings.

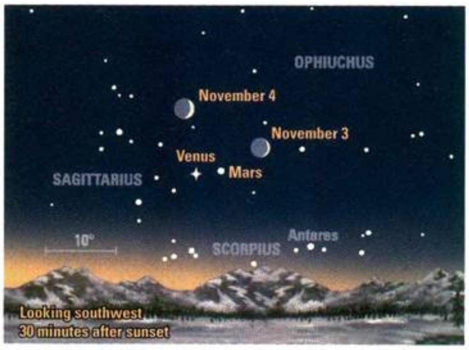
It may be easier to find yellow Mercury first, lying on a line drawn from Jupiter through Venus and Mars. The moon will be a little bit lower than Mercury and considerably farther to the right of the planetary line, 13° or two and a half binocular fields. ■

Martin Ratcliffe directs the Henry Buhl, Jr. Planetarium in Pittsburgh, Pennsylvania. Alister Ling is a meteorologist working for Environment Canada in Alberta.

Conjunction Junction

The solar system struts its stuff this month with planets playing a great part in the drama. Brilliant Venus blazes low in the southwest, accompanied by ruddy Mars. At magnitude 1.1, Mars pales more than 100 times fainter than Venus's magnitude –4.4 highbeam. Mars won't pass the dropping Venus until January. Unfortunately, Mars is a disappointingly tiny disk, just 5" across. Lovely Venus's transformation is significantly more impressive — in the course of a single month its half phase thins while its size doubles to 50".

The crescent moon makes a gradual entry on the evening of November 1; here it is a day and a half old. Because the shallow angle of the solar system plane keeps the action fairly close to the horizon, the moon's prominence in the sky will be limited. On the 3rd and 4th, the moon, Venus, and Mars come together for a picturesque pose.



Lucky North Americans living in the west will get a chance to watch the dark — but likely earthlit — portion of the moon gobble up members of M25, an open star cluster, near 8 p.m. MST (7 p.m. PST) on the evening of the 4th.

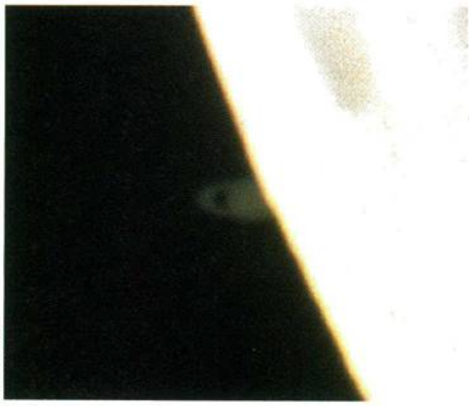
Look a couple of degrees above the horizon after the 10th to find Mercury struggling to be visible in the bright twilight; binoculars will provide the best view.

Saturn Slips behind the Moon

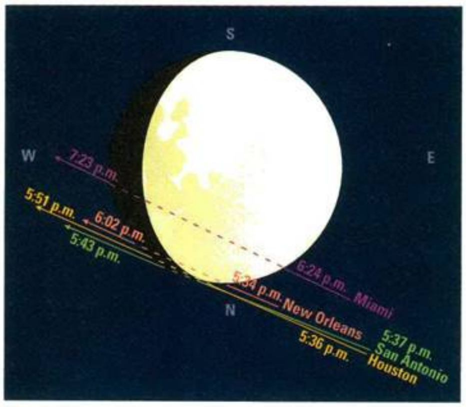
For the second time this year, a few lucky North American viewers will get to witness the orbiting moon sweep across the face of the ringed planet. The fortunate residents south of a line stretching from Boston, Massachusetts, to Houston, Texas, get to witness the spectacle in its glory while the rest of the continent should still enjoy observing a close call.

The event is scheduled to take place on Tuesday evening, November 11, around 8 p.m. EST, as the nearly full moon takes a bite out of the rings. The leading dark limb of the moon will not be visible, so you will have to start a little early and be prepared. A drive on your scope will allow you to relax instead of chasing the pair while you watch. Use medium to high power, 150x–300x, in order to capture the most interesting details.

A complete disappearance will take a bit more than a minute. Use the diagram to judge when and where Saturn will reappear for your location.



Lee Coombs



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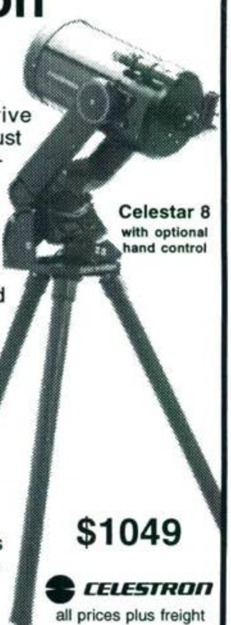

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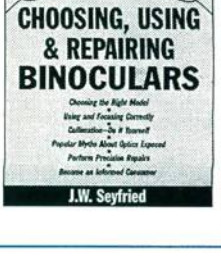
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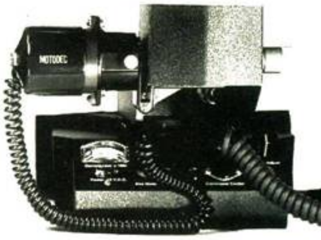

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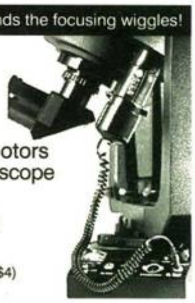

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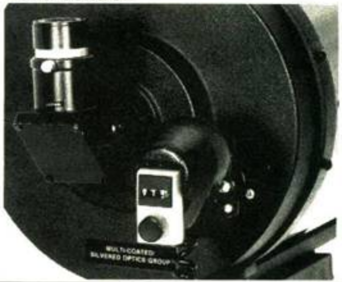

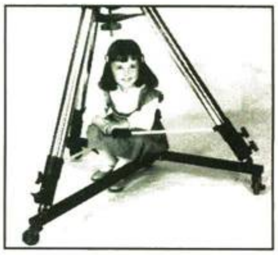

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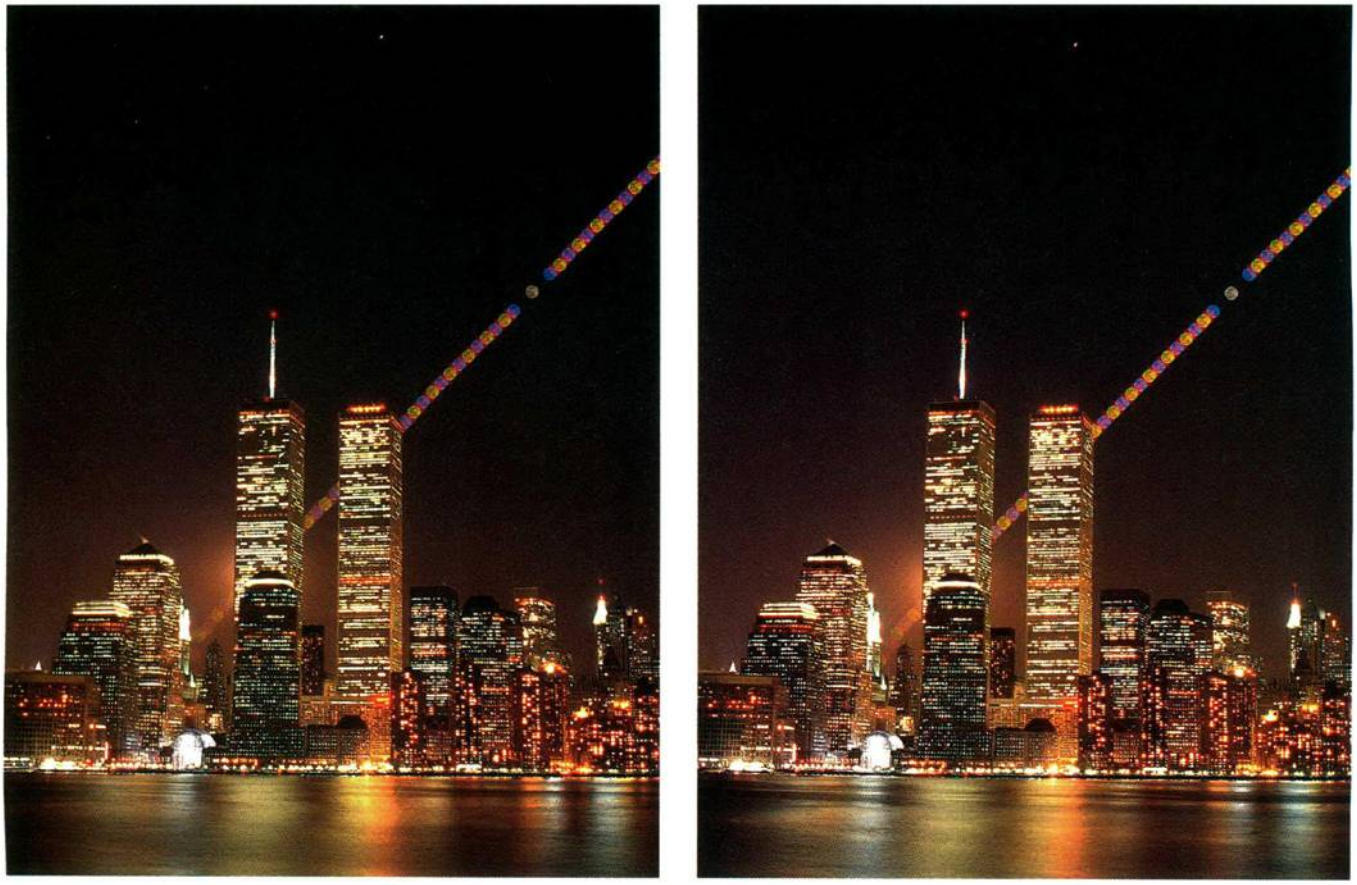
Seeing Double

Are two lenses better than one?

by Larry Landolfi



Reach out and touch the Big Dipper. The author used a flash to highlight the foreground trees to provide depth to the photos.

Unless otherwise noted, all photos by Larry Landolfi

YOU WANT TO TAKE SERIOUS astrophotos like the ones you see in *Astronomy* every month, but you figure everything has already been photographed, right? Perhaps that's true in two-dimensions. But what about a different type of sky-shooting, one where the image seems to jump right off the page? I'm referring to stereo astrophotography. This unusual technique produces photos that present a three-dimensional effect.

Sir Charles Wheatstone invented the stereoscope in 1838 to view some crude, hand-drawn geometric stick figures in his essay, "On Some Remarkable, and Hitherto Unobserved, Phenomena of Binocular Vision." Wheatstone rightly maintained that humans perceive depth because each eye, spread apart by approximately 2½ inches, sees the world in a similar, but not quite identical, way. The human mind combines these two views and interprets them in three dimensions.

Ordinary photographs appear flat because most cameras have only one eye, or lens, able to record height and width. A stereo photograph appears to show depth because a stereo camera's two lenses mimic human eyes.

Stereo photography's history dates almost as far back as Wheatstone's classic paper. In 1839, William Henry Fox Talbot produced the first stereo photographs of statues, buildings, and people. Queen Victoria visited the 1851 World's Fair in London, England, and was so entranced by the stereoscopes on display that the exhibitors presented her with one. She was one of the first to be fascinated by stereo photography.

Left: A multicolored moon rises over Jersey City, New Jersey. With two cameras spread about 40 feet apart, the author exposed the film through red, green, and blue filters exactly 60 seconds apart.

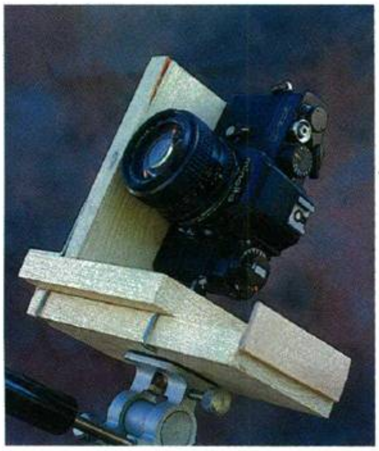
It took 100 years for the stereo craze to reach its peak. In the 1950s alone approximately 40 different stereo cameras were produced. Today, however, sky photographers have significantly fewer options to pursue stereo sky shots. The principal approaches involve using either a stereo camera or using a 35mm camera to make dual exposures of a scene, thereby mimicking the product of the former. Beyond which instrument you use, it's important also to consider the best films and techniques for capturing your own stereo astrophotos.

Get Real(ist)

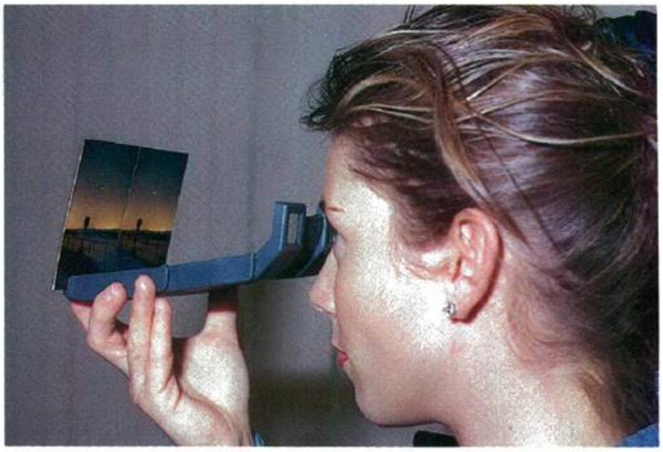
I've owned a Stereo Realist camera for more than 15 years. Nothing photographic I've ever used has given me more pleasure, and no camera's results have been more crowd pleasing. You can still pick one up for $200 to $250 in any good used camera store.

The Stereo Realist camera is ideal because it has two fixed lenses and a "T" setting that lets you keep the lenses open without a cable release. Simply press the shutter button to open the lenses, then press it again some time later to close them. It's also completely mechanical — there are no batteries to drain during long shots, and it's easy to use for multiple exposures. Additionally, its f/3.5 lens is relatively fast and the camera uses regular 35mm film.

I use Kodak's Elite 100 almost exclusively for my slide work. Shooting with this film provides a fairly neutral background during long star-trail shots. Fuji Velvia and



This "slide-bar device" turns an ordinary camera into a stereo camera. After exposing one photo, the photographer moves the camera to the opposite side of the slide bar and makes the next exposure. The result is a stereo photograph that's the next best thing to "being there."



The "Loreo" print stereo viewer, sold by Reel 3-D, makes viewing stereo images easy. But you don't need one. You can also "free-view" images by first holding the page close to your eyes and slowly drawing it away while fixing each eye on the same prominent feature in each picture. Be patient and practice; it's worth the effort.

Kodachrome 25 are equally sharp and provide rich, satisfying color — experiment and see which you prefer.

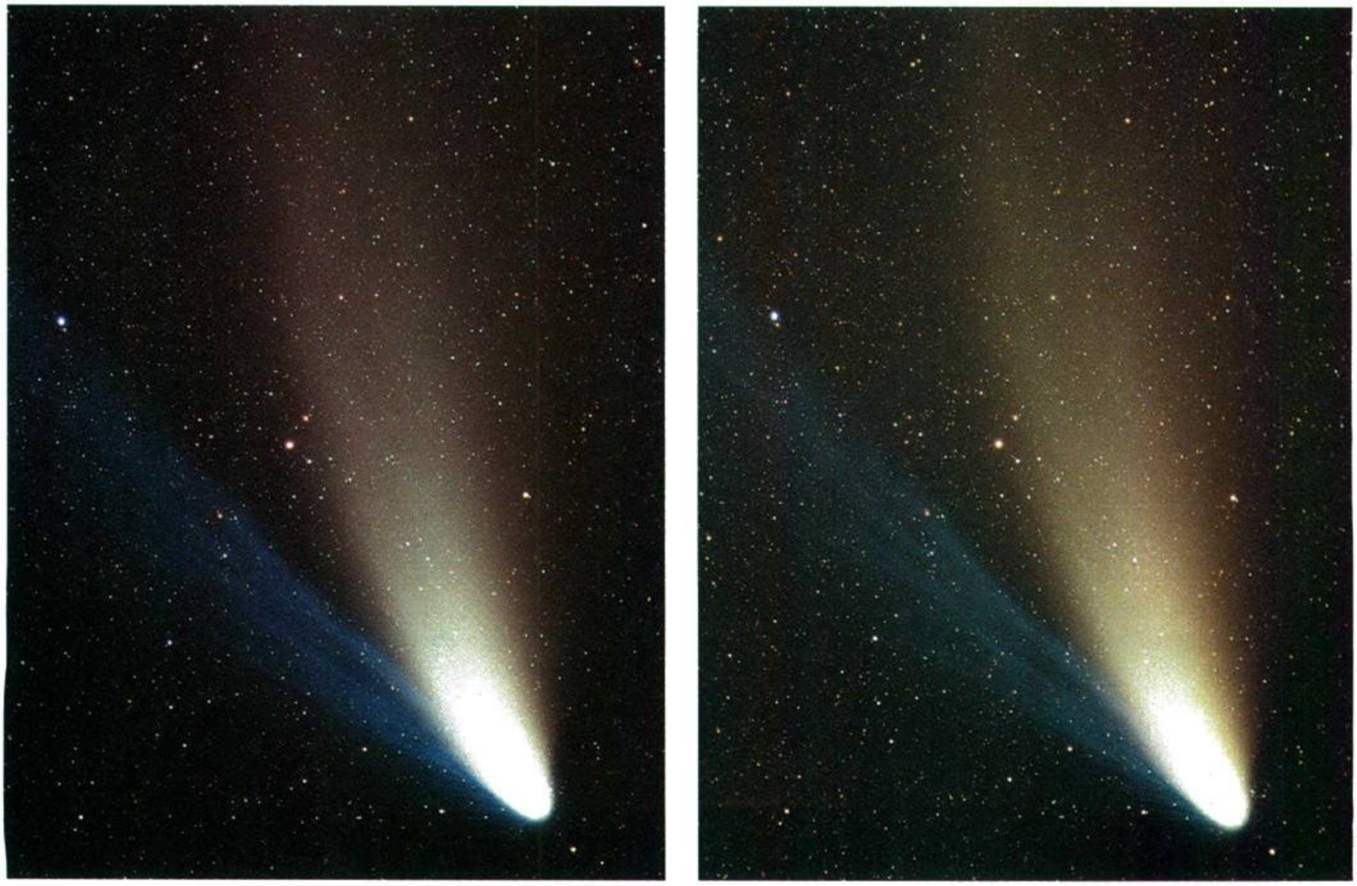
Shooting slide film through a Realist isn't problem-free. In 1986, Kodak closed its stereo slide mounting division, and stereophotographers were left with two options: Find someone else who develops and mounts stereo slides, or have Kodak simply develop the roll and return it uncut (the photographer then cuts and mounts the slides). I chose the latter.

A company called Reel 3-D Enterprises, Inc. (Box 2368, Culver City, CA, 90231; telephone 310-837-2368) can rescue any would-be stereophotographer — it sells everything for 3-D photography.

It is rather time-consuming to mount your own stereo slides and takes practice to become facile. A roll of 36-exposure film yields 30 stereo pairs (a roll of 24 yields 20) and takes me about an hour to cut, align, mount, and seal.

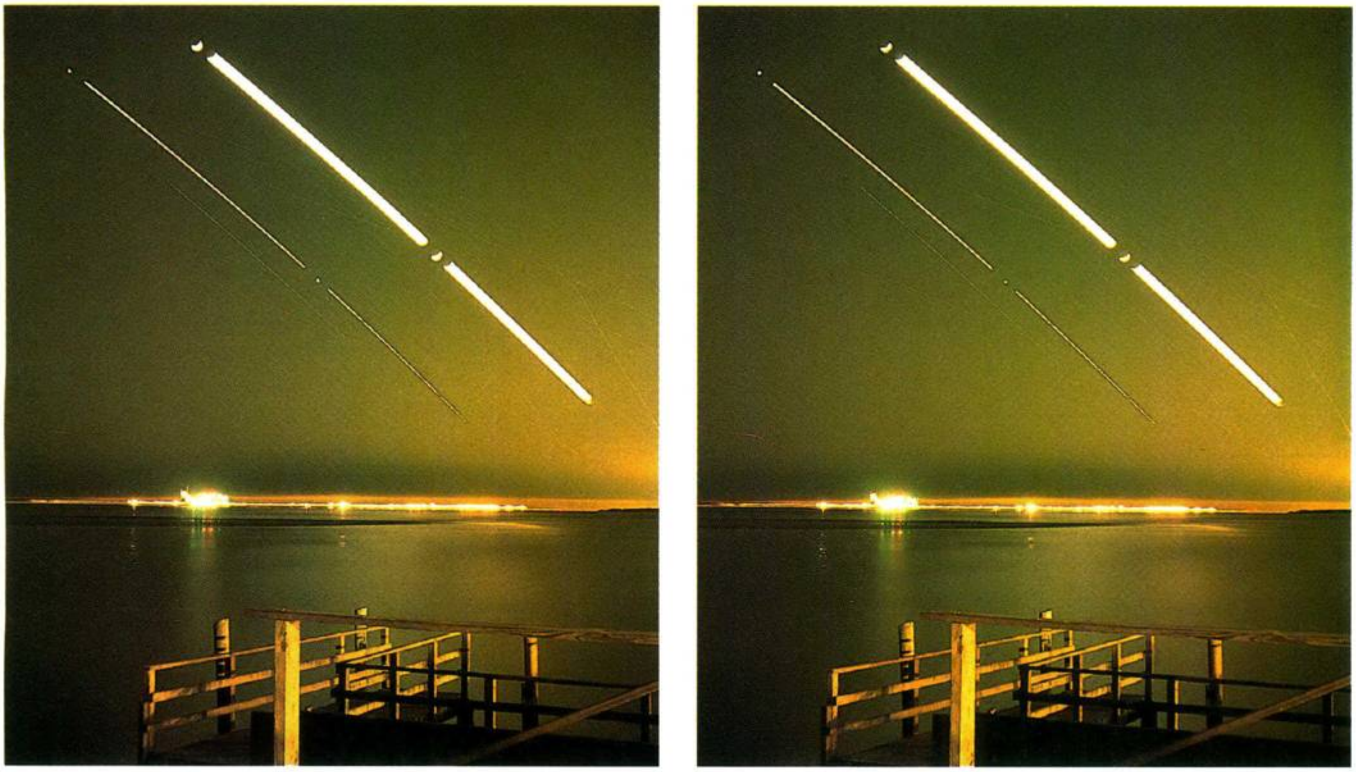
I use print film when taking guided astrophotos, and there are a number of excellent fast films with fairly fine grain. The Fuji 400 and 800 brands, and Kodak's two new films, PPF 400 and Ektapress PJM 640, give excellent results under dark skies.

Exposed film may be sent to Grand Photo, 1681 Grand Avenue, St. Paul, MN, 55105; phone, 612-451-5828.



The "Prime-Time" comet (Hale-Bopp) in stereo. The images were taken one hour apart, and made with a 135mm f/2.5 lens, Fuji Super G Plus 400 film, and 5-minute (left) and 8-minute (right) exposures.

David Copley



To get a strong 3-D effect, you need a prominent foreground. The author set the stage with a pier in New Jersey and shot Venus, Saturn, and the moon setting over Kennedy airport. He used a Stereo Realist camera and Velvia film.

Stereo Photography with a 35mm Camera

Using a stereo camera isn't the only way to get stereo photos. At first, it may seem impossible to take stereo shots with a 35mm camera because it only has one lens. You could use two cameras side by side, but not everyone has that luxury.

It's true that a stereo photograph consists of two slightly different views of the same object, but those views do not have to be taken at exactly the same moment. You can use your regular 35mm camera to take a pair of stereo photographs as long as the two photos are taken as quickly as possible, one right after the other, before the "still life" moves (the stars behind that old tree, for instance). With a little help, you can turn your 35mm camera into a stereo camera.

A slide bar device (see photo) will help you take quick and easy stereo photos. Attach the base of the slide bar to a sturdy tripod, load your camera with Ektachrome 400 slide film, and choose either the horizontal or vertical camera holder.

Put this on the base and slide it all the way to one side. Set your 50mm lens to f/2.8 and focus at infinity. Because Earth's rotation causes stars to trail after 20 to 25 seconds, this is the longest exposure you'll be able to use. Using a cable release will hold the camera steady as the lens is open. Now simply compose your shot by placing some foreground object within about 25 feet of you in the picture frame, and take the first exposure for 20 seconds. (To get a good 3-D effect you'll need to have foreground objects that will appear to stick out in front of the sky background.) Close the lens, advance the film, slide the camera along the bar until it stops, then quickly take another 20-second exposure.

Depending on how dark your sky is, you might have trouble distinguishing it from the foreground using Ektachrome 400. Using a flash on your foreground with each exposure will illuminate it, thereby making it stand out. With a 6-inch camera adapter sliding along an 8½-inch base, you have now taken two photos 2½ inches apart, the same distance apart as your eyes.

Turn Up That Stereo

Whether it be a tree branch or the top of a house, a prominent foreground is essential for a successful stereo photograph and certainly for one involving the night sky. Don't take a picture in an open field or over the ocean, since there is nothing by which to gauge depth. In the photo, you need to show one object within 25 feet of the camera.

You see a gorgeous full moon rising behind a distant cityscape, but you know that anything beyond 300 feet appears flat. You now have a way to add some depth to that shot. Just because our eyes see the world 2½ inches apart doesn't mean that your camera lenses have to. Try a "hyperstereo" shot of the distant object, maybe even with a zoom lens. You're simply performing the slide bar trick, except that now you're moving your whole tripod and camera feet instead of inches between exposures.

Take the first exposure (remembering exactly where you focused) then quickly move either left or right, maybe 20 or 30 feet, to take your second exposure. This is an effective stereo technique, one that produces what I affectionately term the "scale model" effect because it produces a striking, almost artificial-looking set of foreground details.

I've shown you just a few of the ways that it's possible to take stereo astrophotos. With a little ingenuity, there are probably other ways to make a camera (or two) help you see the universe in a new light. What are you waiting for?

Larry Landolfi lives in New York. He loves astronomy and photography, and is happiest when the two can meet. Many of his astrophotos have been published in Astronomy.

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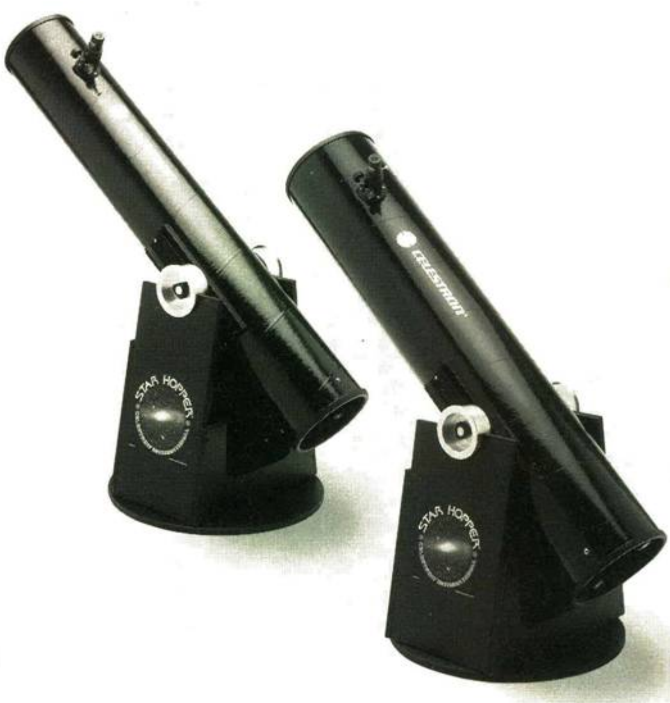

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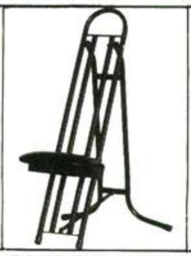

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Intensify the

Night-vision scopes use Cold War technology to light up a whole new sky. **by Gregory Terrance**

Brightness

Adjusting the viewer's gain, or sensitivity.

When mail arrives, my first impulse is to set aside the bills and grab the astronomy stuff. There's always a catalog filled with telescopes, eyepieces, binoculars, and accessories. Page after page is plastered with color photographs of the moon, planets, deep-sky objects, and, of course, all sorts of equipment. But one type of equipment has always caught my eye: night-vision scopes. The ads boast 20,000x light amplification and sometimes feature a picture that shows a night owl bathed in green light, completely unaware that someone was snapping its picture.

Wow! With that much light boost, a night-vision scope should be great for astronomy. As an astronomer, I understand that a telescope's light grasp improves as its diameter (aperture) increases. That's why larger telescopes can see fainter objects. But would the light amplification of a night-vision scope be equivalent to light grasp? When *Astronomy* magazine e-mailed me one day asking if I wanted to test the DN-42 Multi Night Vision Scope, a new night-vision system offered by the Orion Telescope and Binocular Center, I could not resist a search for the answer.

Crossing Over

Until recently, the use of night-vision scopes has been restricted to military and scientific fields because of their high cost. However, political changes in Europe have led defense manufacturers, both in the east and west, to look for civilian applications for their products. As CCD cameras have migrated from the professional astronomer to the backyard astrophotographer, night-vision devices have shifted from military to civilian use. These devices are a big hit and their prices are dropping steadily.

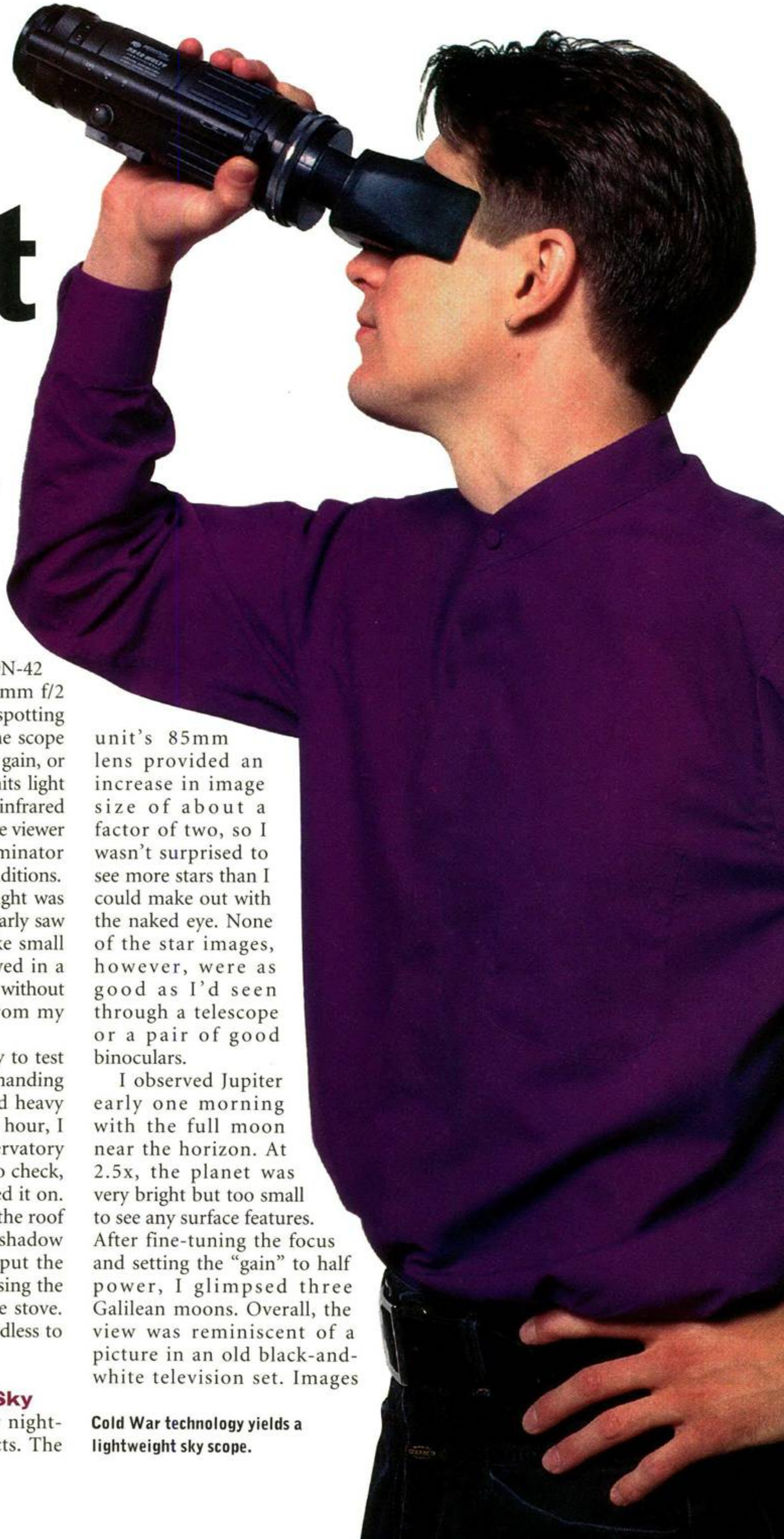
Last spring a Russian-made night-vision scope arrived at my doorstep. I opened its green camouflaged case and found the scope and two viewer fittings. One

NEWCON OPTIK

The DN-42 outfits with two viewer fittings, adapters, and a carrying case.

All photos by *Astronomy*: Jim Forbes

Night



is for viewing with two eyes, the other for monocular use. The fittings provide a 1.9x and 2.7x increase in image size respectively. Each comes with eyecups to keep stray light from interfering with the view. The DN-42 also comes with camera and video adapters. Orion sells the entire outfit for $1,260.

Weighing in at a hefty 3½ pounds, the DN-42 is about 11 inches long and sports an 85mm f/2 objective, giving it the look and feel of a spotting scope. Two small knobs on each side of the scope turn the unit on and adjust the intensifier's gain, or sensitivity. A side-mounted illuminator emits light in the infrared part of the spectrum. This infrared "flashlight" casts a beam of light visible to the viewer but invisible to the human eye. The illuminator comes in handy for low-light or no-light conditions.

My first experience with the scope at night was amazing. Under a moonless, dark sky, I clearly saw clouds passing overhead. Stars looked like small flashlights. Fields behind my house glowed in a green light. Bales of hay completely invisible without the scope showed up as plain as day. From my porch I could see a rabbit foraging for food.

A few nights later I had an opportunity to test the scope's abilities under some more demanding conditions. During a storm that produced heavy rains and wind gusts of over 40 miles per hour, I wondered if I had locked down my observatory roof. Rather than get dressed and go out to check, I grabbed the night-vision scope and turned it on. Through a downpour I could not only see the roof was safely closed, but also make out my shadow against the observatory 200 feet away. I put the scope down to look for what could be causing the shadow. It came from a small light on the stove. All of the other house lights were out. Needless to say, I was impressed.

Night Scope under a Starry Sky

During subsequent tests, I aimed my night-vision scope at all sorts of celestial objects. The unit's 85mm lens provided an increase in image size of about a factor of two, so I wasn't surprised to see more stars than I could make out with the naked eye. None of the star images, however, were as good as I'd seen through a telescope or a pair of good binoculars.

I observed Jupiter early one morning with the full moon near the horizon. At 2.5x, the planet was very bright but too small to see any surface features. After fine-tuning the focus and setting the "gain" to half power, I glimpsed three Galilean moons. Overall, the view was reminiscent of a picture in an old black-and-white television set. Images

Cold War technology yields a lightweight sky scope.

The 85mm f/2 lens has f-stop and focusing rings.

were slightly "fuzzy" due to noise in the system and some dark and light dots shimmered throughout the field of view. I've since found out that these effects are caused by variations in the intensifier's phosphor tube.

The scope is focused with the turn of a ring near the 85mm objective lens. I tried both eyepiece fittings and found that the monocular worked better for focusing. The fitting for two eyes introduced distortions that made objects toward the edge of the field appear less sharp than objects near the center. Objects seemed to "snap" into focus with the monocular, while the binocular viewer exhibited a softer image. The only drawback to using the monocular eyepiece is its reduced field of view, a factor I didn't find very troublesome.

I couldn't pass up the chance to view Comet Hale-Bopp with the scope. Although the comet was low and no longer at its brightest, it still was a worthy target. Using the night-vision scope with its monocular fitting attached, I found that stars near the comet appeared much brighter than they looked to the naked eye. This created the illusion that the comet was closer. Surprisingly, I didn't

The ABCs of Night Vision

Night-vision scopes (image intensifiers) require ambient light to operate. The amount needed is a function of the technology used. The equipment comes in many styles, including monocular, binocular and goggled. All use a green display phosphor, giving a monochrome view in differing shades of green (because the human eye can differentiate more shades of green than other colors). You don't really look "through" a night-vision device; you look at the amplified electronic image on a phosphor screen.

Here's how the process works: A front lens collects small amounts of undetectable ambient light and focuses it on the image intensifier, which converts light energy (photons) into electrical energy (electrons). The electrons pass through a microchannel plate, which multiplies them thousands of times. Then, a highly-intensified electron image strikes a phosphor screen that emits a "picture" of the image.

Because of this amplification process, night-vision devices should not be used in daylight or near bright light sources. While no harm will come to the user, prolonged exposure to bright light sources will lead to a reduction in intensifier amplification. (And the intensifier accounts for 75 percent of the entire unit's cost.)

At the heart of a night-vision scope is a phosphor tube that boosts ambient light.

The night-vision industry has evolved through many generations of development (Generation 0, 1, 2 and 3). The first night-vision scopes (G0 and G1) were developed in the 1960s and offered a 1000x boost in light amplification. The development of a Microchannel Plate in the early 1970s led to the birth of Generation 2. These devices increase light amplification to a whopping 20,000 - 30,000x. The G1 and G2 scopes multiply primarily the visual spectrum of light. A current "state-of-the-art" Generation 3 device provides an incredible 50,000x light amplification and operates in the visible and near-infrared regions. Due to its greater infrared sensitivity, a G3 device "sees" more light and delivers nearly a threefold improvement in visual perception and detection distances.

Be sure to shop around before you buy a night-vision scope. Prices for the same model often range between $300 and $900. There are also units on the market with refurbished intensifiers. While the prices of "reconditioned" systems may be attractive, the hours of remaining life and performance cannot be restored to new levels. In fact, some reconditioned units may operate at below acceptable minimums.

Viewing attachments let the night-vision scope work as a monocular or binocular.

notice much improvement in the appearance of Hale-Bopp's ion and dust tails. Even though the comet's nucleus was brighter, I couldn't see more detail. I compared comet views with a pair of 7x50 binoculars. The view was noticeably better than through the night-vision scope. Star images and Hale-Bopp's dust tail were definitely sharper through binoculars.

The following night I wanted to see how the scope fared with some of the better-known Messier objects. I started with M51 because it is bright, easy to find, and nearly overhead. Lying on my back, I pointed the scope toward a patch of sky where I knew M51 would be hiding. The 2.5x monocular eyepiece revealed the galaxy as a small, elongated patch of light. The scope's limited visual resolution prevented me from distinguishing M51's two interacting galaxies into the separate blobs I've often seen in low-power telescopes.

I also had success finding M3, M13, and M101. The globular clusters proved to be easy targets for the night-vision scope. They looked like bright, unfocused stars standing out against the sky background. The galaxy M101 proved to be a more difficult subject. I was just able to distinguish it through the view screen's snowy noise. None of the deep-sky targets revealed much detail. Overall, I found the night-vision scope didn't work as well on smaller extended objects as it did on point sources.

The night scope excels at showing macro features along the Milky Way. Huge emission regions like the North America Nebula stood out extremely well, as did star clouds in Scutum and Sagittarius. Many dark nebulae scattered through the southern Milky Way into Cygnus were very well defined.

After using the scope for a while I found my eyes were no longer dark adapted. In fact, I found the screen's light intense enough to double as a dim flashlight. Deep-sky observers can avoid this problem by viewing through the scope's monocular with one eye while keeping the other "in reserve" for telescopic use.

Nighttime Redefined

After factoring in all these considerations, would I buy a night-vision scope for astronomy? The answer is a qualified "maybe." During the two weeks that I evaluated the scope, its limitations for viewing celestial objects were obvious when compared to binoculars and telescopes. On the other hand, these scopes are incredible tools for naturalists of the night.

A night-vision scope is an ideal companion for those who travel to a dark site or remote observatory. Objects become visible in near-daylight detail — no more tripping over tree limbs, losing dropped eyepieces, or wondering what caused a branch to snap in the middle of the night. In the final analysis, these powerful devices are somewhat limited for conventional astronomy. But their knack for revealing some aspects of the sky as well as other sights of the night is nothing short of astonishing. ■

Gregory Terrance (gregoryt@frontiernet.net), an active astro-imager specializing in planetary images, enjoys the night sky from his observatory in upstate New York.

The Generation Gap

Night-vision scopes cross a wide range of capabilities and usually include a "G" (generation) designation that gives you an idea of what they can and cannot do.

G0 - Requires an infrared light source.

G1 - Incorporates an image-intensifier tube and operates only with available ambient light. Low performance.

G2 - Incorporates a microchannel plate to provide improved spectral sensitivity. Tube life is longer in a smaller, lighter unit.

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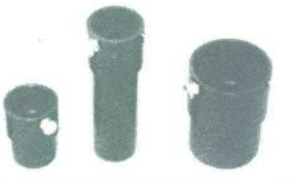

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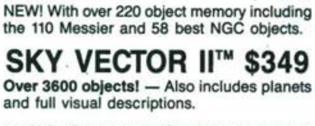

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The New LUMICON Multiple Filter Selector holds up to 5 1¼" LUMICON filters. The sliding bar has a click-stop at each filter position. Now you can instantly select the best filter for any deep-sky object. Cost is $129 or $185 with 1.5X relay lens (for Newtonians). **Save $30 if ordered with filter(s)!**

TELE VUE™

NEW! Bino Vue Binocular Viewer

Genesis-SDF 4" f/5.4 apochromat	**$2125**
Pronto 70mm f/6.4 apochromat w/2" diagonal	**$969**
Pronto 70mm f/6.4 w/45° erecting prism	**$839**
NEW! Bino Vue binocular viewer	**$899**
Gibraltar mount with ash wood tripod	**$535**
10.4, 26mm Plossl 50°	**$79**
8, 11, 15mm Plossl . **$95**, 20, 25mm	**$105**
32mm Plossl, widest true field in 1¼"	**$125**
55mm 2" Plossl, widest possible field	**$235**
2.0x or 3.0x Tele Vue Barlow Lens	**$119**
2" Giant Barlow - 2x	**$185**
15mm Wide-Field, 1¼" eyepiece, 65°	**$139**
4.8mm Nagler, 82° field, 1¼" eyepiece	**$175**
7mm Nagler, 1¼" eyepiece, 82° field	**$225**
9mm Nagler, 82° field, 1¼" or 2"	**$245**
13mm Nagler, 82° field, 1¼" or 2"	**$315**
12mm Nagler, Type II, 82°, 1¼"/2"	**$295**
16mm Nagler, Type II, 82°, 1¼"/2"	**$315**
20mm Nagler, Type II, 82°, 2" only	**$395**
2" Paracorr Visual Coma Corrector	**$259**
15mm Panoptic 1¼", 68° field	**$215**
19mm Panoptic 1¼", 68° field	**$245**
22mm Panoptic 1¼"/2", 68°	**$285**
27mm Panoptic 2", 68° field	**$335**
35mm Panoptic 2", 68° field	**$365**

TeleVue Warranty may not be valid outside USA.

NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding up to an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32"	**$39.50**	1.52"	**$45.00**	1.83"	**$49.50**
2.14"	**$59.50**	2.60"	**$75.00**	3.10"	**$99.50**

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	**$99.50**
2" (1.83" mirror)(see photo above)	**$189.50**

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.
LUMICON Adjust. Piggyback Mount $59.50
Specify telescope size: 6", 8", 10", 11", 14", 16"

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the LUMICON Deep-Sky (DS) Filter.

Specify Lens Size	**H-Alpha**	**(DS)**
46, 48, 49mm	**$59.00**	**$199.50**
52, 55, 58, 62mm	**$69.00**	**$199.50**
67, 72, 77mm	**$79.00**	**$399.50**
82mm (77mm + adapter)	**$89.00**	**$415.00**

Hypered 2415 film, 36 exp .. **$11.95, $3/$32**

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LUMICON FILTERS — BEST IN THE WORLD!

"The LUMICON O-III proved to be our favorite... It gave the greatest contrast gain." ***ASTRONOMY*, February 1991**

AMAZING O-III FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

GREATLY ENHANCED DETAIL

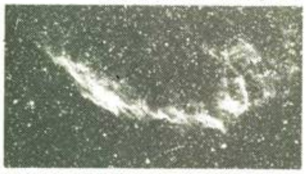
"Consistently performed well on all emission and planetary nebulae. Detail and structure were greatly enhanced in the more than two dozen objects I viewed." ***SKY & TELESCOPE*, July 1995**

BETTER THAN A DARK-SKY SITE!?

"From my light polluted backyard, the view ... was better with the O-III than with any other filter tested. The view was even better than without the filter from a dark-sky site." ***SKY & TELESCOPE*, July 1995**

SEE THE HORSEHEAD!

*"**LUMICON's H-Beta Filter** will show subtle features in emission nebulae that the others fail to reveal. It can't be beat for the elusive Horsehead and California nebulae. . ."* ***SKY & TELESCOPE*, July 1995**



"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

BEST for Astrophotography!

"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for BOTH color and black and white photography.

BEST WIDE-BAND FILTER!

*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."* ***ASTRONOMY*, February 1991**

	Premium*
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1¼" LUMICON DEEP-SKY Filter threads into most 1¼" eyepieces	**$99.50**
48mm LUMICON DEEP-SKY Filter (1.7" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS	**$199.50**
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	**$199.50**
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $10, 82mm $16)	**$399.50**
2" Rear Cell Filter, fits SCT's ... Deep-Sky, **$199.50** UHC, O-III, H-Beta,	**$199.50**
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces	**$99.50**
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces	**$199.50**
Choice of ***any two*** LUMICON filters (**Save 7%**) ... 1¼" **$185.00**; 48mm	**$370.00**
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"** ... **$99.50, 48mm**	**$199.50**
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines ... 1¼" **$99.50; 48mm**	**$199.50**
LUMICON Comet (Swan band) Filter ... 1¼" **$99.50; 48mm**	**$199.50**
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm	**$7.95**
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece	**$19.50**
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece	**$25.00**

**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

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†U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

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Temperature controller for any HYPER-KIT **$75**

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All **LUMICON EASY-GUIDER™** off-axis guiders⁶ have both radial and 360º rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360º camera rotation, large prisms for bright guide-stars. ⁶U.S. Patent 4,448,500
Specify Camera and Telescope type.

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER	**$189.50**
48mm Coma corrector/field flattener	**$285**
3X Relay Diagonal (see photo)	**$99.50**
Illuminated reticle eyepiece, pulsed	**$109.50**

Guider for Hasselblad **$489,** Mamiya 645 **$259**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

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For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

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Adapter for Hasselblad **$399,** Mamiya 645**$149**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

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1. **Illuminated reticle eyepiece** ... $109.50
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, pulsed.

2. **Cable release** for long exposures . **$9.95**

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5. **LUMICON EASY-GUIDER** (selection to left)

6. **LUMICON 48mm DEEP-SKY FILTER $199.50**
This is essential for highest possible contrast. Contrast is boosted up to 3X for ***both*** color or black & white photos. The 3 photos in this ad showing the Helix Nebula, Horsehead Nebula and Veil Nebula were all made using a LUMICON 48mm DEEP-SKY FILTER.

7. **Hypersensitized film.** Purchase from LUMICON or make your own with a LUMICON HYPER-KIT.

TRY PPF! HYPERSENSITIZED FILM

SR1600
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HYPERED FILM IS 2-10X FASTER!

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

Film Type, 35mm	**Exposures**	**Price**
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2415, Ultra-fine B&W, red sens.	36	**$11.95**
SR-G3200, fastest of all, color neg	24	**$13.95**
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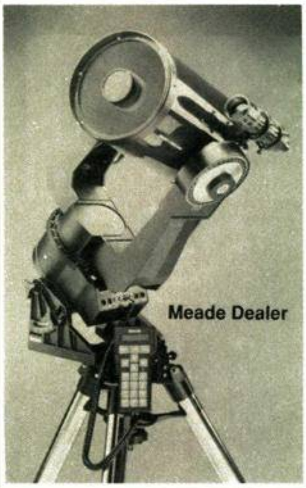

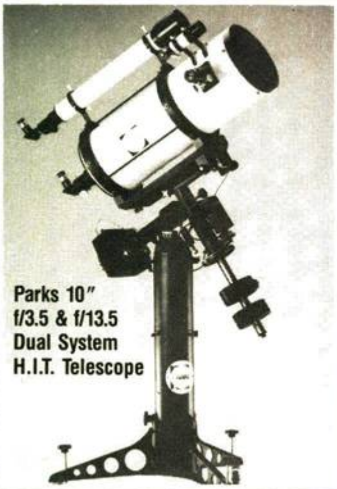

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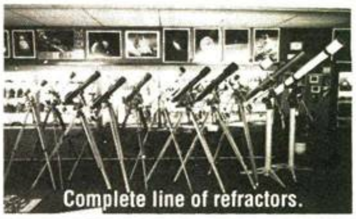
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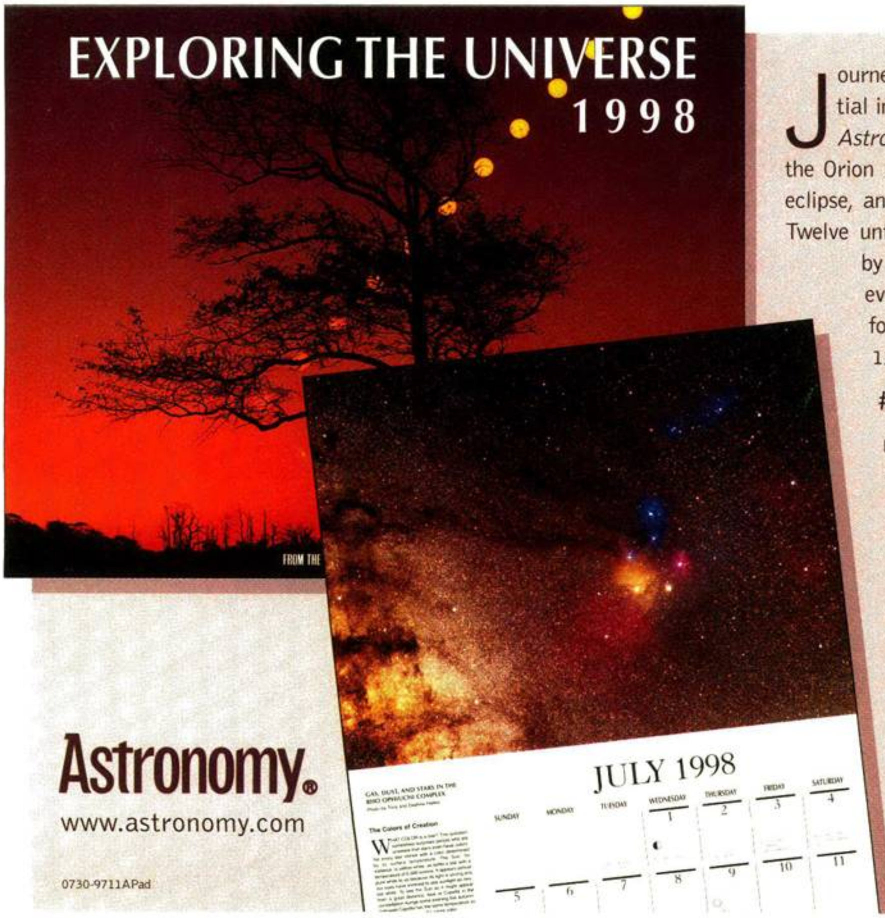

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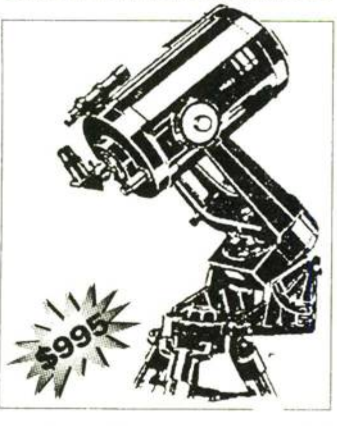

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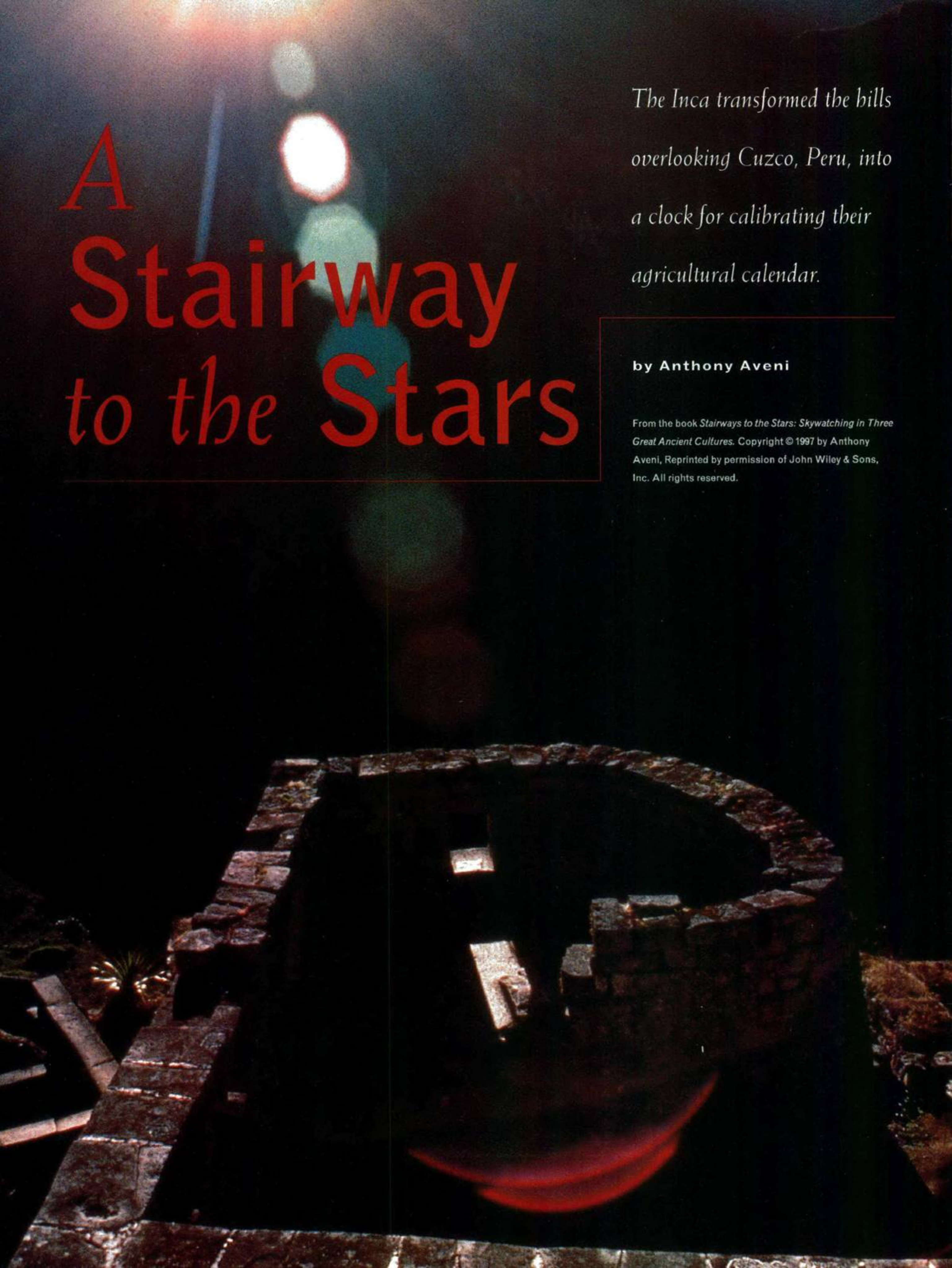

A Stairway to the Stars

The Inca transformed the hills overlooking Cuzco, Peru, into a clock for calibrating their agricultural calendar.

by Anthony Aveni

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WHEN I THINK OF WORLD CAPITALS PLANNED FROM the ground up, Brasília and Washington come to mind. But consider the Inca nobles who conquered territory from Ecuador to Chile just a few generations before the Spanish contact with the New World. They outdid anything European architects might have had in mind when they built Cuzco, the capital of the Inca empire in the highlands of southern Peru. Imaginary sight lines radiated like the spokes of a wheel reaching out from the Temple of the Ancestors, the navel of the Inca world, to the extremities of the empire and the universe. These invisible lines (they called them *ceques*, meaning "rays") divided all the universe into kin-related groups. Cuzco's great urban plan also tied together the sacredly held organization of land, water, mountains, and even the stars. It was literally a map of the world graphed and plotted on top of the world itself, cast in a reference frame of religious worship based on sacrifice and offering to a living entity of which all people were a part.

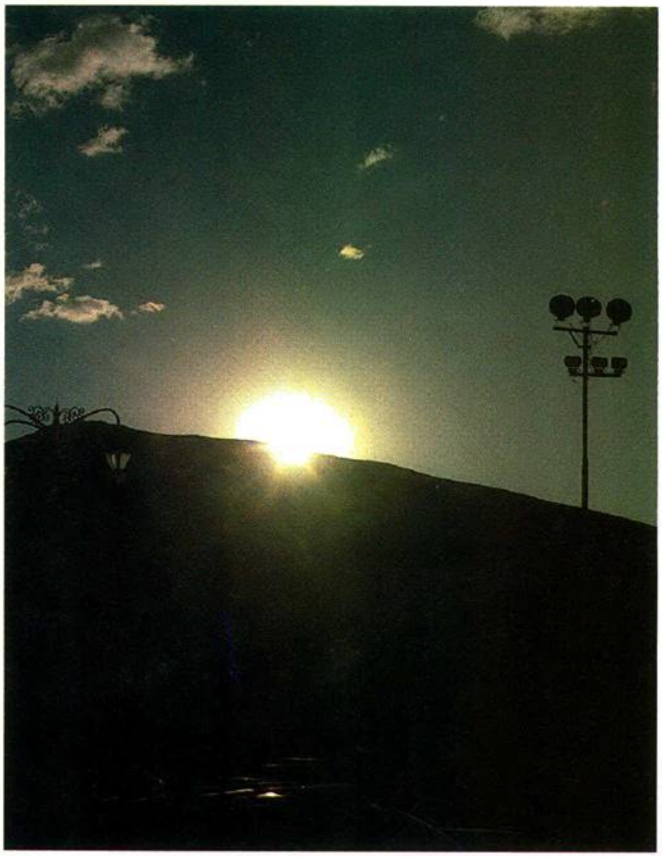
Astronomy was among the concepts incorporated into the *ceque* system of Cuzco. Indeed, these Quechua-speaking Indians established a vast empire that reigned supreme in the region from about 1400 A.D. to the 16th century. The Inca (the word derives from "prince" or "male of royal blood") built observatories with windows to catch the first and last rays of the sun. Their detailed astronomical alignment schemes appear to have made use of observation points connected to high mountains surrounding Cuzco. There, particular *huacas* (sacred places) along the visible horizon were employed to mark the positions of important celestial objects at times of the year deemed worth noting. By directly sighting sunrises and sunsets over particular huacas, the Inca preserved an accurate record of the most important dates of the seasonal year without needing to write it down.

City and Cosmos: Astronomy and the Inca Empire

Just as Aztec legend claims descent from the remains of a once great culture, so too Inca legend tells of its people being born of the sun god, *Inti*. He reigned at the city of Tiahuanaco, impressive for its stately stone sculpture and a famous semisubterranean temple, the capital and ceremonial center of an empire that once stretched around the southern reaches of Lake Titicaca, 300 miles southeast of Cuzco. The first Inca, four generations of brother and sister pairs, were said to have traveled underground, finally emerging at Pacaritambo, a mythical cave overlooking the place where the gods had instructed them to drive their staffs into fertile ground — the valley of Cuzco.

Thanks to the writings of Cieza de Leon and other Spanish chroniclers, Cuzco is one of the few places in the Americas where, even though only a small portion of its once stereotypical walls of exquisitely carved polygonal andesite blocks remain, we nonetheless have some reliable data on how pre-Columbian cities were planned and organized. Scientific studies have demonstrated that Andean concepts of both time and space are inextricably bound to religious, social, and political organizing principles, all of these being embedded in the structural plan of the city. The system that binds these elements together is Cuzco's radial layout, an expressive form that seems special in Andean society, and a plan that incorporates Inca knowledge of the sky.

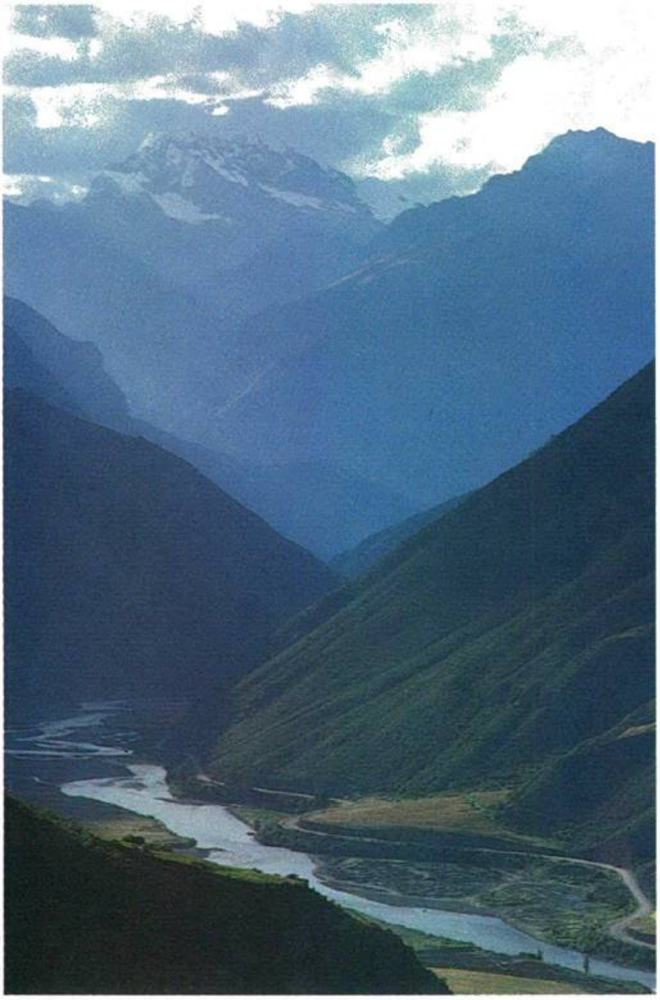
The dawn rays of solstice slice through a window cut to align with a carved edge on the central stone in the Torreon at Machu Picchu. The Torreon is believed to have many similarities with the Coricancha in Cuzco. Although guidebooks suggest that the large rock in its center was a sacrificial altar, astronomically, the windows built into the walls and carvings on the rock align with Winter Solstice Sunrise in June and the rising of the Pleiades. Some archaeoastronomers think that a shadow casting device was supported at the window with the aid of peg holes found on its outer surface. Peter Frost/Wilderness Travel


Anthony Aveni

The sun still sets in the same place it did in Inca times over Cerro Picchu on August 18, the anti-zenith solar passage date. However, 500 years ago it would have been positioned between two of the four towers (since destroyed) that were used to time the planting of crops in the vertical eco-zones of Cuzco.

There is little doubt that the Inca watched the heavens closely and that they developed a precise calendar based on what they saw. Much of their sky watching likely took place in the Coricancha ("golden enclosure"), the Temple of the Ancestors, also called by the Spanish the Temple of the Sun. From the Spaniards' descriptions of it when they arrived in 1533, it must have been a marvelous structure. It was highly ornate with a huge golden sun disk facing the great luminary as he rose. Historian John Hemming recounts one chronicler's description of the place and how the Spaniards looted it:

"These buildings were sheathed with gold, in large plates, on the side where the sun rises, but on the side that was more shaded from the sun the gold in them was more debased. The Christians went to the buildings and with no aid from the Indians — who refused to help, saying that it was a building of the sun and they would die — the Christians decided to remove the ornament . . . with some copper crowbars. And so they did, as they themselves related." The Spaniards pried off seven hundred plates, which Xerez [the chronicler] reported as averaging some 4½ pounds of gold each when



Gary Ziegler/Adventure Specialists

An earthly representation of the Milky Way? The Inca may have believed the Urubamba River to be just that. Here the river runs through the Sacred Valley, which stretches from the town of Pisac to Machu Picchu, the lost city of the Inca.

melted down. "The greater part of this consisted of plates like the boards of a chest, three or four palmos (2–2½ feet) in length. They had removed these from the walls of the buildings, and they had holes in them as if they had been nailed."

Today, like so many important pre-Columbian buildings, the Coricancha is covered over by a Spanish church, the Church of Santo Domingo. But enough of it has been excavated to reveal that it consisted of a rectangular enclosure (*cancha*) fronted by four buildings of cut stone with thatched roofs. The fact that gold (*qori*) adorned the building has given rise to its name, the "Golden Enclosure." It must have been a truly important edifice, on par with the Church of the Holy Sepulchre in Jerusalem.

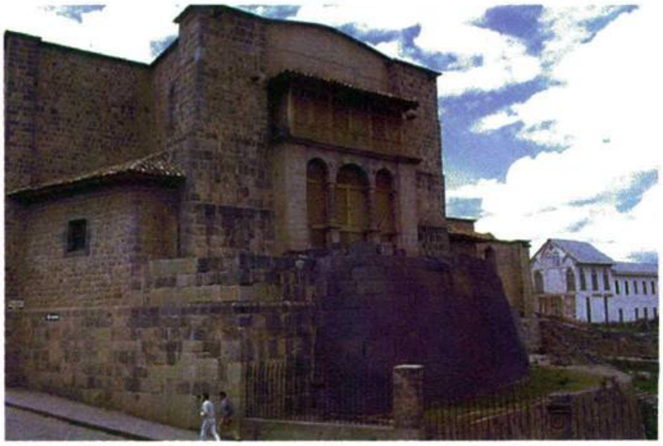
This temple of the ancestors also was dedicated to the most important heavenly bodies worshipped by the Inca: the sun, the moon, Venus, and the Pleiades. Venus, the attendant to the sun, was recognized as the same body whether it appeared ahead of or behind the sun. They observed its heliacal [just before sunrise] rising and setting. The planet was thought to have been ordered by the sun to go sometimes before him (as morning star) and sometimes behind (as evening star) but always to remain close by. According to Spanish chronicler Garcilaso de la Vega:

"Another hall, next to that of the moon, was dedicated to the planet Venus, the Seven Kids [Pleaides], and all the other stars. The star Venus they called *Chasca*, meaning 'having long curly hair.' They honored it saying that it was the sun's page, standing closest to him and sometimes preceding and sometimes following him. The Seven Kids they respected for their peculiar position and equality in size. They thought the stars were servants of the moon and therefore gave them a hall next to that of their mistress, so that they would be on hand to serve her. They said that the stars accompanied the moon in the sky, and not the sun, because they are to be seen by night and not by day."

Inca cosmology had two basic structural principles: dualism and vertical hierarchy, both of which persist and figure prominently in Inca alignment schemes. That all things should come in twos is not an idea unique to the Inca worldview. Day and night, winter and summer, male and female — these themes give rise to the idea that order consists of paired opposites. Even our modern model of the microcosm rests on the principles of positive and negative charge, and the big bang theory began with the differentiation of the universe into matter and radiation. A second paragon of order more peculiar to those who live in a mountain environment consists of the "up and down" classification. Anyone who takes a car trip from the coast to the Andean highlands can experience the extraordinary variation in Andean ecology in a single day. Within a few hours you rise from the warm, foggy maritime environment of Lima, Peru's capital city, to frigid tundra-like passes bordered by snow-topped mountains 18,000 feet high.

Each zone along the ascent exhibits its own micro-climate and productivity: from cotton fields, cactus, tree fruit, squash and fisheries on the coast, to maize in the middle altitudes, and to ever hardier varieties of potatoes and related tubers as you rise to the elevated plateaus, or *puna*, where herders graze their llamas and alpacas. Anthropologist John Murra has demonstrated that in Inca times, control of these vertically arranged economic zones was maintained by systematically relocating people and enacting strict laws dictating who should have access to farmland within each region. Even where inhabitants could live within each region was regulated by law — a clear indication of the extraordinary degree of organization that existed within the empire.

The Church of Santo Domingo was built on top of the Coricancha, which remains partially visible today. The Coricancha was defaced by the Spanish after their arrival to Cuzco in 1533.



Jack Newton

This view of the "Lost City of the Incas" exemplifies how the Inca terraced their land for building and farming. The Spanish never found Machu Picchu, which sits about 2,300 feet above the Urubamba River. The city remained uninhabited after the Inca left it until 1911, when it was rediscovered by Hiram Bingham. Peter Jevne

The hallmark of urban social organization in Cuzco was the *ceque* system. It was a giant cosmographic map, a mnemonic device built into Cuzco's natural and man-made topography, which served to unify Inca ideas about religion, social organization, calendar, hydrology, and astronomy. The Spanish Jesuit chronicler Bernabe Cobo, from his *History of the New World,* written in 1653, describes the system:

"From the Temple of the Sun as from the center there went out certain lines which the Indians call ceques; they formed four parts corresponding to the four royal roads which went out from Cuzco."

He further describes and locates in detail these imaginary radial lines, and indicates that they emanated from the Coricancha at the city's center.

Astronomical Alignments in the Ceque System

One of the most important orientations in Cuzco had to do with the sun's position during the planting season. An anonymous chronicler tells us that the Inca constructed four pillars on a high hill overlooking Cuzco from the west; the inner and outer ones were separated by 200 paces, while the two middle ones were 50 paces apart:

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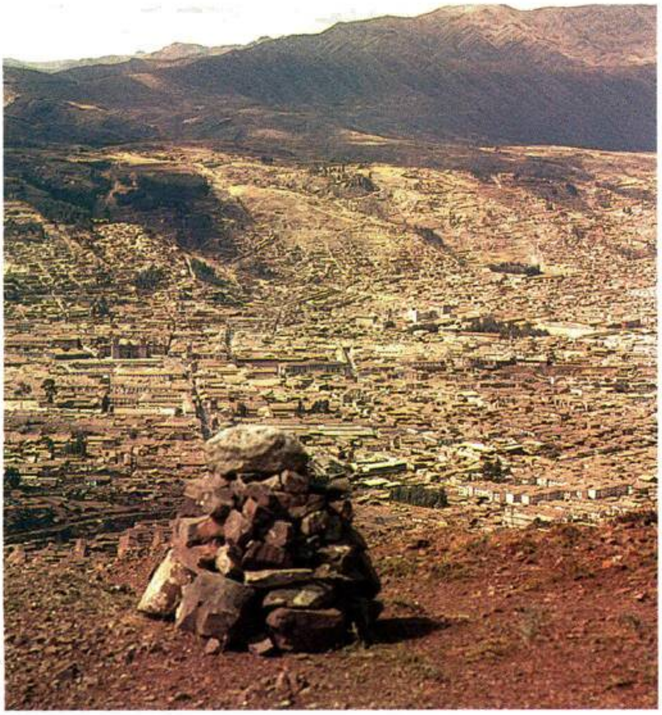
Anthony Aveni

View overlooking Cuzco from the site of one of the "Picchu Sun Pillars." The author's research group marked the spot with a pile of rocks. The Inca made careful observations of the sun's shadow on sun pillars to determine when crops should be planted.

"When the sun passed the first pillar this began the time when they were warned about the planting of vegetables at the highest altitude. When the sun entered the space between the two pillars in the middle it became the general time to plant in Cuzco, always the month of August. And when the sun stood fitting between the two inner pillars they had another pillar in the middle of the plaza . . . called the 'Ushnu,' from which they viewed it. This was the general time to plant in the valleys adjoining Cuzco."

The hill to the west of Cuzco turns out to be the prominent mountain named Cerro Picchu, the summit of which lies two kilometers from the present town square where the *ushnu* was located. Today a cathedral overlooks the *ushnu* site, but antizenith sunset (August 18 at Cuzco's latitude) still occurs on a precipitous downslope just north of the summit. At the supposed distance from the site of the cathedral, the inner pillars would frame 1° of the horizon (two solar diameters), while the "200 paces" from the first to the last pillar translates to 4°, or eight sun disks, of angular separation. This means about 15 days would have been required for sunsets to migrate across the zone marked by the pillars, thus providing a reasonable delay interval for planting at different altitudes in the vicinity of Cuzco. Garcilaso also talks about the pillars (which he says he saw still standing in 1560) as being

The Inca Trail is a walking route that ascends approximately 6,560 feet through the mountains above the Urubamba River in Peru. It follows the course of an ancient Inca roadway that leads to Machu Picchu, high in the Andes.

Angus McIntyre

A golden sun disk such as this one was covered in gold and set atop the Temple of the Sun, the Coricancha, in Cuzco. It faced the great luminary as it rose. This reproduction resides in the Coricancha.

Dave Hardy

arranged in groups of four; he implies, however, that the Inca ruler had erected more than one set of them and that they were used to mark the solstices. He is quite explicit about Inca sun-watching methods:

"To ascertain the time of the equinoxes they had splendidly carved stone columns erected in the squares of courtyards before the temples of the sun. When the priests felt that the equinox was approaching they took careful daily observations of the shadows cast by the columns."

How do archaeoastronomers interpret these alignments? We know that one of the most important timings in the Inca calendar was the traditional date of the start of the planting season, a day occurring in mid-August when the sun arrived at its position opposite the zenith. Evidently the times for planting in different terraced elevations in the vertical environment of Cuzco were marked out by the day-to-day horizontal course of the sun across the row of pillars.

What stands out about the Inca is the way they used the natural order they perceived in the landscape as a means of structuring their social order. The *ceque* system functioned like clockwork only when each particular class performed its assigned function in the proper place along its *ceque* line at the correct time of year. Thus, the people of Hanan [upper, located in the northwest] Cuzco were in charge of the June solstice observations and offerings, while those in Hurin [lower, located in the southeast] Cuzco took care of the December solstice. In this confrontation between nature and culture, in a harsh, difficult, and changeable agricultural environment, the *ceque* system served to map out and prescribe proper human action based upon residence and kinship in a radial, subdivided geographic framework.

There is irony in the way contemporary astronomy has developed. As our machinery penetrates ever deeper into the microcosm and farther out into the macrocosm, so, too, it functions to form the barrier between ourselves and our ancestors' view of nature.

In this example from the world of the Inca we see astronomy being put to use in ways a modern astronomer could not have imagined. The sky will forever fascinate those of us who look up at it. Ptolemy once wrote: "In studying the convoluted orbits of the stars my feet do not touch the earth, and seated at the table of Zeus himself, I am nurtured with celestial ambrosia." My guess is that the astronomers of the ancient Andes, whose unwritten records we have only begun to explore, would have understood how Ptolemy felt.

Anthony Aveni is the Russell B. Colgate Professor of Astronomy and Anthropology at Colgate University. His most recent book, Stairways to the Stars: Skywatching in Three Great Ancient Cultures *explores the astronomies of the Inca, Maya, and early astronomers at Stonehenge.*

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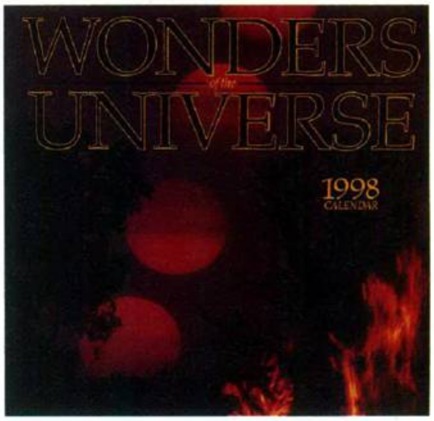
Hansen Planetarium Publications, 1845 South 300 West, #A, Salt Lake City, UT 84115-1804; phone, (801) 483-5400, (800) 321-2369; fax, (801) 483-5484. *Wonders of the Universe 1998*: $11.95.



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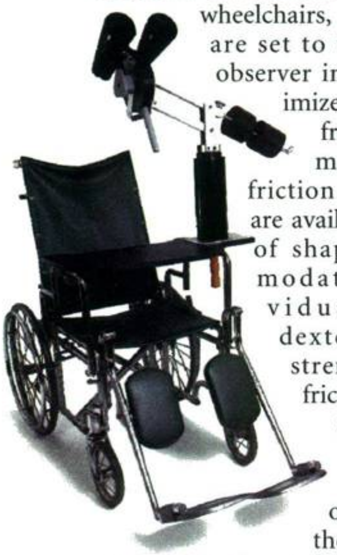

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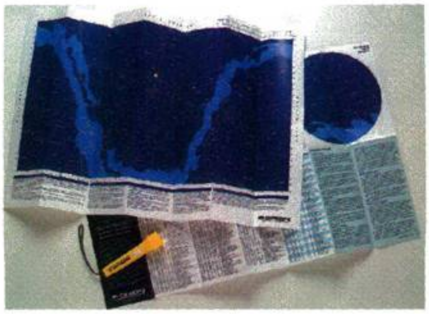

BOOKS

Before the Beginning: Our Universe and Others

Martin Rees, 304 pages, Addison-Wesley, Reading, Mass., 1997; ISBN 0-201-15142-1, hardcover, $25.

Hunting Down the Universe: The Missing Mass, Primordial Black Holes, and Other Dark Matters

Michael Hawkins, 240 pages, Addison-Wesley, Reading, Mass., 1997; ISBN 0-201-15698-9, hardcover, $25.

▶ Those interested in cosmology have an embarrassment of riches to choose from this year. First, Timothy Ferris weighed in with *The Whole Shebang: A State-of-the-Universe(s) Report*, an excellent survey of cosmology and quantum physics (*Astronomy*, July 1997). Now, two British astronomer-cosmologists provide their insights into the state of the universe.

Sir Martin Rees, Astronomer Royal and professor of astronomy at Cambridge University, takes the reader on a tour of modern cosmology, describing some of the high points in the search for an understanding of the nature of our cosmic environment. To begin with, he shows how the Big Bang came to be the standard theory of the origin of the universe and reviews what we know about redshifts, dark matter, and gravity. He continues to his central theme, namely, what would be the con-

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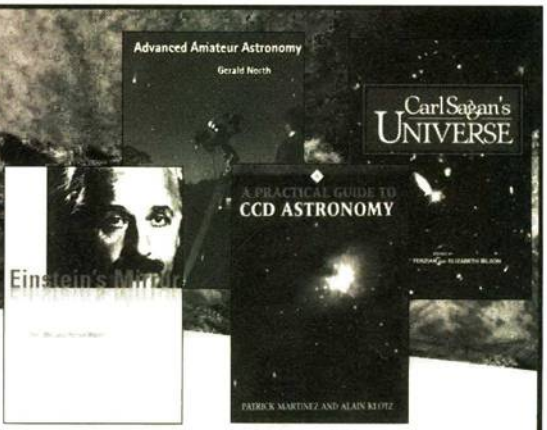

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This fascinating and beautifully-illustrated collection of articles features a distinguished team of authors, including Philip Morrison, Frank Press, and Paul Horowtiz, and covers the many fields in which Sagan worked. The book includes thought-provoking discussions of such topics as the search for life on Mars, the possibility of time travel, the importance of science education, and the impact of global climate change. There is also a special chapter by Sagan himself, dealing with space travel and our place in the universe.

1997	282 pp.	
57286-X	Hardback	$59.95
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A Practical Guide to CCD Astronomy

Patrick Martinez *and* ***Alain Klotz***

Beginning with a no-nonsense introduction to CCD cameras, the authors explain what determines camera performance and demonstrate how to use a CCD camera and accurately calibrate the images obtained. The book also presents a clear review of the software available for visualizing, analyzing and processing digital images. Finally, the authors navigate a series of key areas in astronomy where astronomers can make the best use of CCD cameras.

Practical Astronomy Handbooks 8

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Drawing on oral histories, archival material, as well as the author's personal participation from 1956 to the present, this is a personal account of a period of major innovation in American optical astronomy. It will be of interest to historians and astronomers alike.

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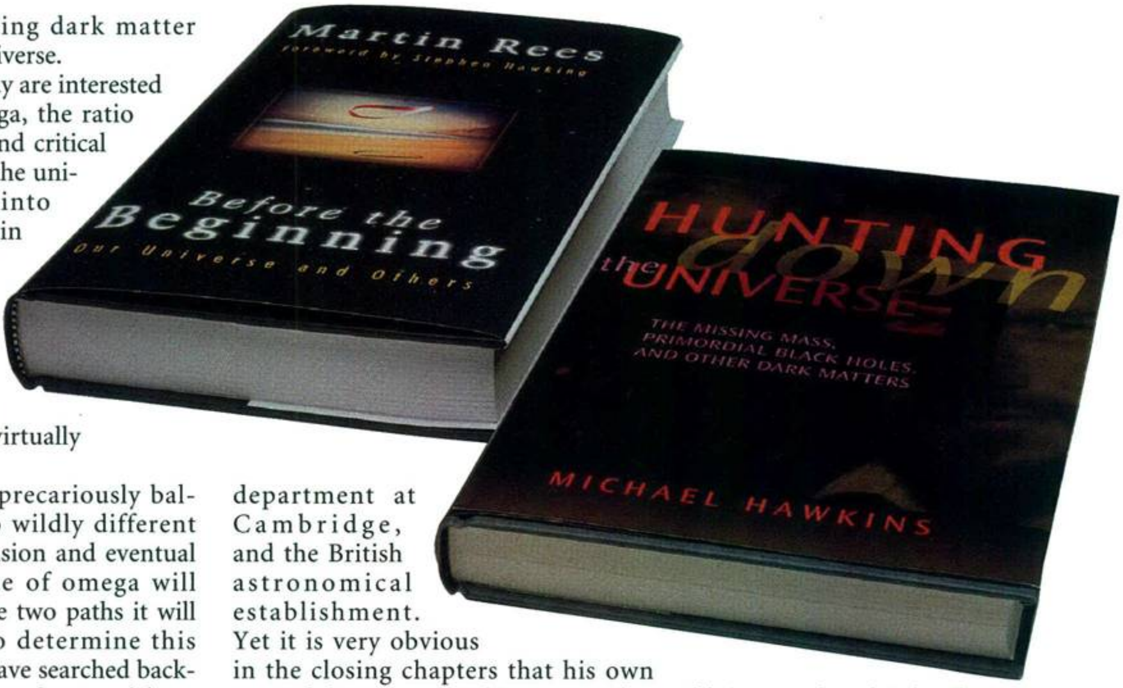
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foreword by Stephen Hawking
Before the Beginning
Our Universe and Others
HUNTING down the UNIVERSE
THE MISSING MASS, PRIMORDIAL BLACK HOLES, AND OTHER DARK MATTERS
MICHAEL HAWKINS

sequences of locating dark matter somewhere in the universe.

Cosmologists today are interested in the value of omega, the ratio between the actual and critical density of matter in the universe. Rees goes into some detail to explain why many cosmologists believe that this value is close to one, that the actual and critical densities of matter in the universe are virtually equivalent.

Our universe is precariously balanced between two wildly different fates: limitless expansion and eventual collapse. The value of omega will indicate which of the two paths it will follow. In order to determine this value, astronomers have searched backwards, seeking to understand how events that occurred within the first millisecond after the Big Bang produced our visible universe. He speculates that the reason the observable universe appears flat is because we see only a very small part of the total universe. There's much beyond the horizon of our instruments that hasn't come into view. This discussion leads into consideration of multiple universes and what might happen to our universe billions of years in the future.

Michael Hawkins, an astronomer at the Royal Observatory in Edinburgh, presents his research on the missing mass problem and uses it to illustrate the way science actually works, paying attention to the social, anthropological, and psychological aspects of the scientific process. Critical to understanding the process, in his view, is an understanding of the conflict between rational and empirical approaches to science. Thus he includes an extensive discussion of philosophers Wittgenstein and Popper, illustrated by the conflict between big bang and steady state views of the universe and between Newtonian and quantum physics.

It is apparent in the opening chapter that Hawkins has an ax to grind, and grind he does. He takes on religion, "big" science such as the Hubble Space Telescope and similar space projects favored by Americans, the astronomy department at Cambridge, and the British astronomical establishment. Yet it is very obvious in the closing chapters that his own research has benefitted in any number of ways from all of these.

Once into the latter half of the book, readers are treated to a fascinating discussion of the missing mass problem as Hawkins builds his case piece by piece. Baryonic matter, matter made up of protons and neutrons, only accounts for ten percent of the mass needed to reach critical density, the point at which the universe would be in equilibrium, neither expanding nor contracting. Both Hawkins and Rees agree that conventional dark matter would account for no more than another ten percent. So where is the rest? Hawkins leads the reader through his research on microlensing to conclude that it lies in primordial black holes, each with a mass equal to that of Jupiter.

Hawkins portrays himself as the upstart questioner of accepted wisdom while Rees presents the majority view. But the final chapters of *Before the Beginning* are extremely speculative, delving into the question of multiple universes, odd bodies, and such. *Hunting Down the Universe*, on the other hand, ends like a research report, reluctantly placing the research results in the realm of logical speculation.

Both astronomers are excellent writers, making a complex subject understandable to the uninitiated. While neither is the equal of Ferris, *Hunting Down the Universe* reads much like a novel and is hard to put down once it gets going. Both will provide plenty of food for thought and entertainment for those long winter nights when blizzards rage outside. — *Stephen H. Peters*

In Search of Planet Vulcan: The Ghost in Newton's Clockwork Universe

Richard Baum and William Sheehan, 310 pages, Plenum Press, New York, 1997; ISBN 0-306-45567-6, hardcover, $28.95.

▶ Nope, this book isn't about *Star Trek*'s Mr. Spock. It's about the enigmatic planet Vulcan, the planet that never was. Astronomers in the 19th century noticed that Mercury was not behaving according to Newtonian mechanics, so the great French mathematician Urbain Jean Joseph Le Verrier — whose calculations led to the discovery of Neptune — proposed that the gravitational influence of an inner planet was causing the discrepancy. This book tells the tale of those who searched for the mystery planet and those who supposedly found it, demonstrating the human propensity to see what one wants to see, whether it's there or not. Obsession, rivalry, frustration, controversy, misplaced optimism — it's all here in this long overdue book by two masterful storytellers, both of whom have previously written for *Astronomy*.

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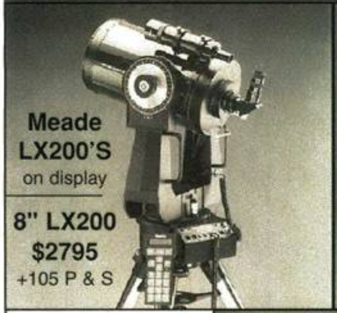

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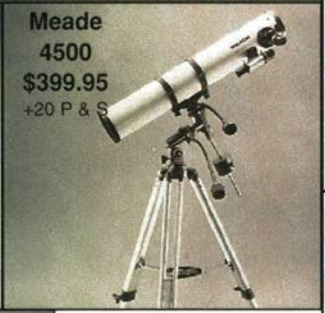

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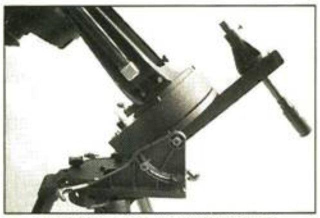

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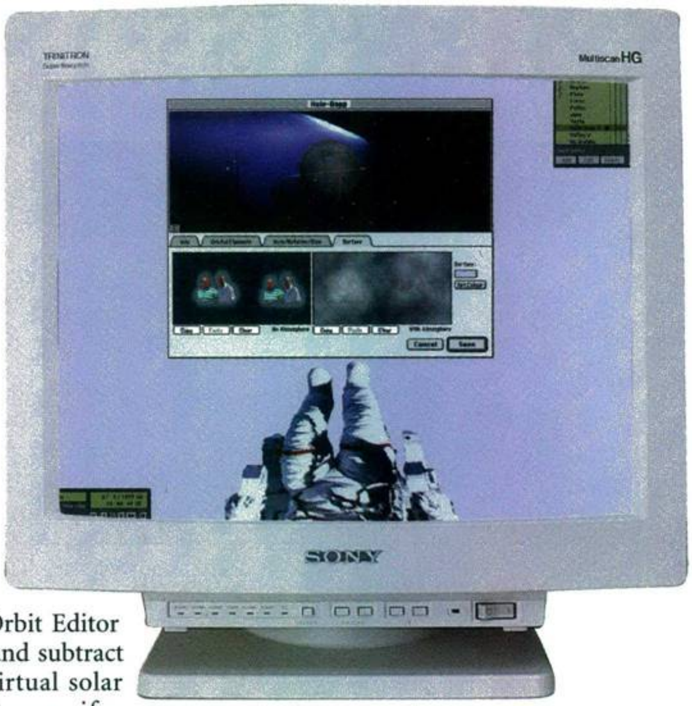

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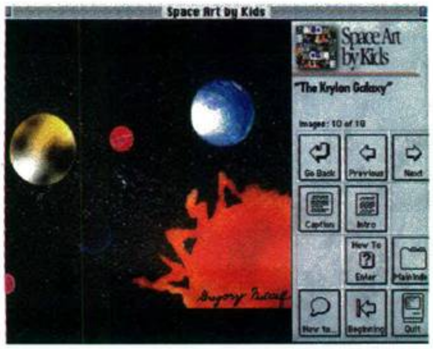

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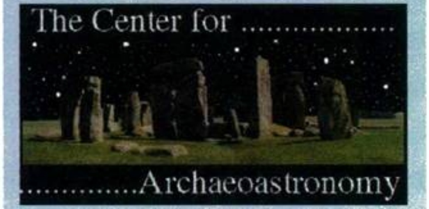
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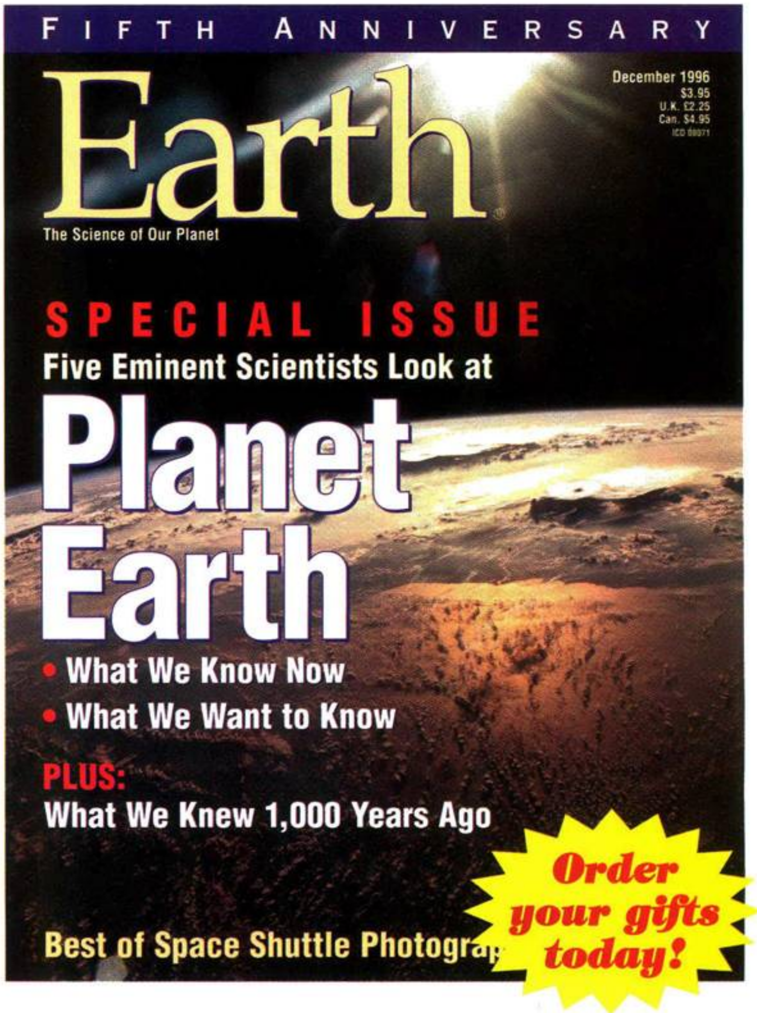
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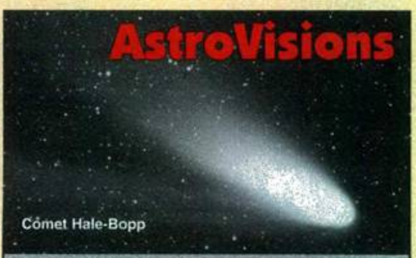

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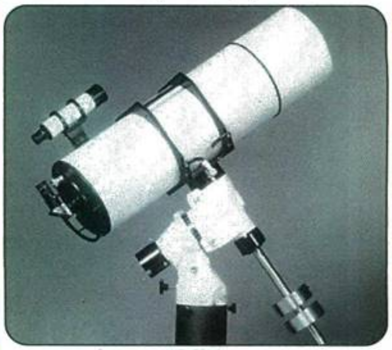

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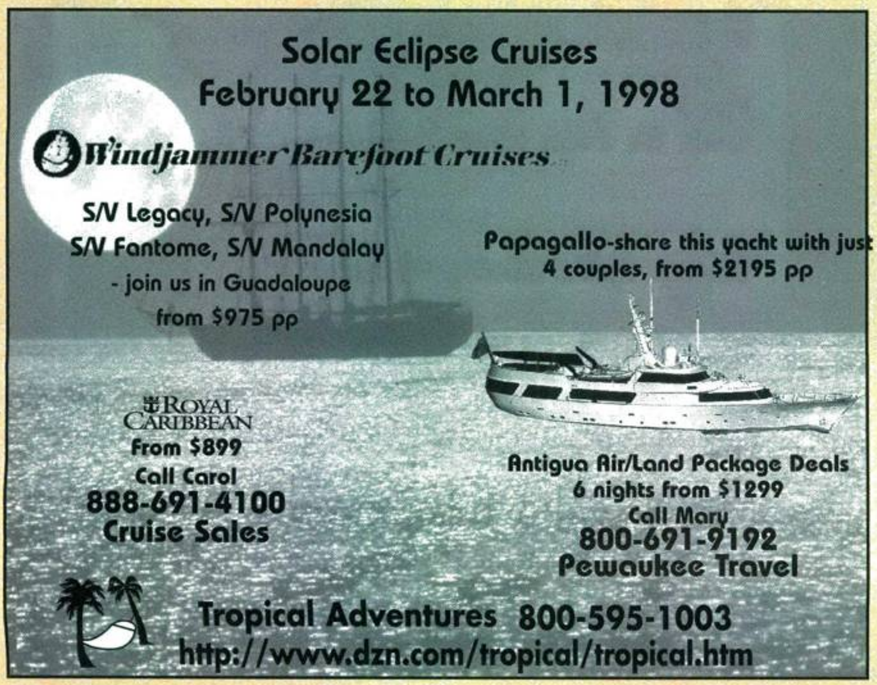

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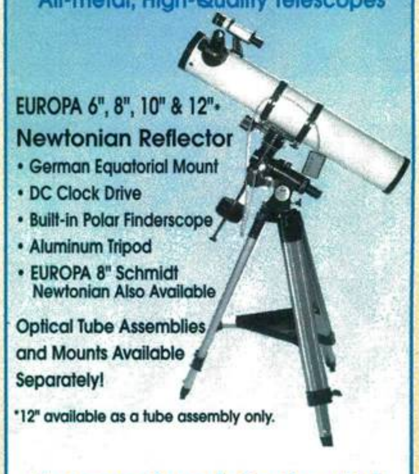

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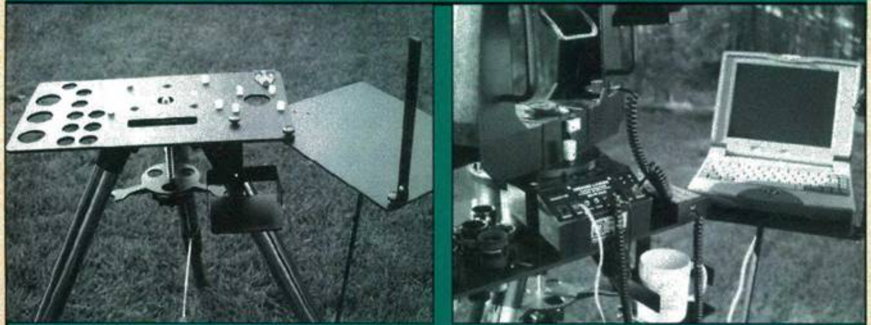

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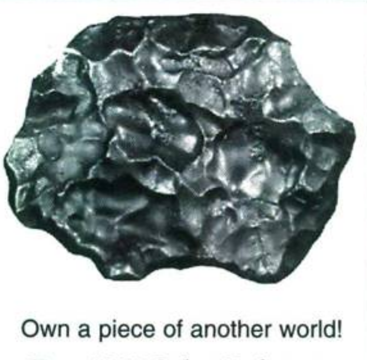

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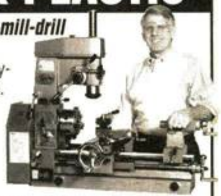

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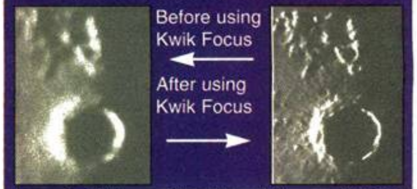

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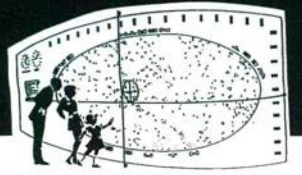

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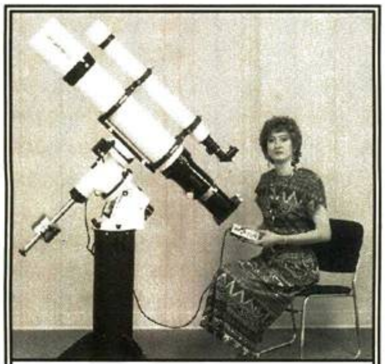

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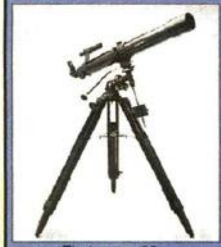

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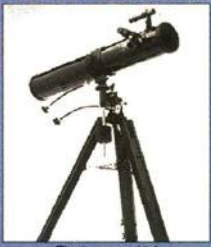

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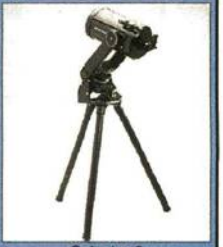

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Visitors to this year's Rocky Mountain Star Stare '97 pose for a shot at Tarryall Meadows near Lake George, Colorado. *Astronomy*'s Photo Editor, Patti Kurtz, attended the event this past June, along with 214 other skywatchers.

Mark A. Brown

The 86th Annual Meeting of the American Association of Variable Star Observers will be held **October 24–26** at Mount Holyoke College in South Hadley, Massachusetts.

The AAVSO is the largest organization of variable star observers worldwide, with members in more than 40 countries. Its purpose is to coordinate variable star observations made largely by amateur astronomers, evaluate the accuracy of these observations, compile, process, and publish them, and make them available to researchers and educators.

The AAVSO receives more than 300,000 observations yearly, from 550 observers worldwide More than 8.5 million observations of variable stars have been compiled since the founding of the AAVSO in 1911.

Bring your horse and telescope to the **Fall Central Texas Star Party** from **October 31–November 1**. The gathering will take place at Pedernales Falls State Park in the scenic Texas hill country. Ride your horse and explore the unusual geology of the Pedernales River by day; enjoy dark skies with minimal horizon obstruction by night. The star party is free; however, park entrance and camping fees will be charged.

The warm air and clear skies of southern Florida draw nearly 600 astronomers and families to the **Winter Star Party** each year. The 1998 event will be taking place on West Summerland Key, an island in the Florida Keys, **January 26–February 1**. Although physical space limits capacity, there may still be time to secure a reservation.

OCTOBER 24-25
Starry Nights Festival

▶ Joshua Tree National Park, Blackrock Canyon Campground, Yucca Valley, California. Contact Tim Robertson, 2110 Hillgate Way #L, Simi Valley, CA 93065; (805) 584-6706; e-mail, trobert@earthlink.net.

OCTOBER 24-26
Annual Meeting of the American Association of Variable Star Observers

▶ Mount Holyoke College, South Hadley, Massachusetts, and the Comfort Inn and Conference Center, Chicopee, Massachusetts. Contact AAVSO, 25 Birch Street, Cambridge, MA 02138; (617) 354-0484; e-mail, aavso@aavso.org.

OCTOBER 29-NOVEMBER 2
Deep South Regional Stargaze and Southeast Region of the Astronomical League Convention

▶ Percy Quin State Park, near McComb, Mississippi. Contact Barry Simon, 820 Emerald Street, New Orleans, LA 70124; (504) 283-7592; e-mail, ssimon@accesscom.net.

OCTOBER 31-NOVEMBER 2
Mount Magazine Star Party

▶ Mount Magazine, Arkansas. Sponsored by the River Valley Stargazers. Contact Jim Bielaga, 1591 Pollard Cemetery Road, Dover, AR 72837; (501) 331-3773.

OCTOBER 30-NOVEMBER 3
Mid Atlantic Star Party

▶ Boy Scout Camp Reeves, 10 miles south of Robbins, North Carolina. For more information, send a SASE to MASP, 244 Deerfield Road, Apex, NC 27502; (919) 362-5194; e-mail, john@bsa.net; website, http://www.bsa.net/masp.

OCTOBER 31-NOVEMBER 1
Fall Central Texas Star Party

▶ Pedernales Falls State Park near Johnson City, Texas. Sponsored by the Austin Astronomical Society. Contact (512) 252-2966; or the AAS website, http://www.main.org/aas/activity.html#centex.

NOVEMBER 8
Free Star Party

▶ Ralph Worley Observatory, Highway 175, south of Shreveport, Louisiana. Sponsored by the Shreveport-Bossier Astronomical Society. Contact Cran Lucas, (318) 797-1524, e-mail, clucas@softdisk.com; website, http://www.lsus.edu/nonprofit/sbas/.

DECEMBER 6-7
Fifth Central American Congress for Amateur Astronomer Associations

▶ Centro Loyola, Calle Teotl, Colonia Altos de Guadalupe, San Salvador, El Salvador. Sponsored by the Salvadoran Astronomy Association. Contact Ana-Gui Reyes, VIPSAL #1416, P.O. Box 02-5364, Miami, FL 33102-5364; phone in El Salvador, (503) 278-8888, ext. 3117; fax, (503) 278-3079; e-mail, anagui@ sal.gbm.net.

JANUARY 26-FEBRUARY 1
Winter Star Party

▶ West Summerland Key, Florida Keys. Sponsored by the Southern Cross Astronomical Society. Contact Mike Barrs or Therese Rubenstein at 3403 Poinciana Avenue, Miami, FL 33133; (305) 441-2428; e-mail, wsp@scas.org. For information about accommodations call (800) FLA-KEYS.

RESOURCES

Bound for the Ringed Planet (page 36) and Destination Titan (page 42)

The New Solar System, by J. Kelly Beatty and Andrew Chaikin, editors, Third Edition, (Sky Publishing Corporation, 1990). Written by leading planetary scientists, this overview of the solar system contains information about Saturn and a chapter on Titan.

Imaging Saturn: The Voyager Encounters to Saturn, by Henry S. F. Cooper, Jr., (Holt, Rinehart, and Winston, 1982). A highly readable account of the Voyager flybys of Saturn.

Saturn, by Garry Hunt and Patrick Moore, (Michael Beazlyt Publishers, 1982). An introductory guide to the saturnian system, this book contains many photos and maps.

Observatory of Legends: Yerkes at 100 (page 50)

Pauper and Prince: Ritchey, Hale, and Big American Telescopes, by Donald Osterbrock (University of Arizona Press, 1993). The compelling story of the founding of Yerkes Observatory, emphasizing Hale's moody and complicated personality.

Yerkes Observatory, 1892-1950, by Donald Osterbrock (University of Chicago Press, 1997). The authoritative history of the early days of the Yerkes Observatory.

Into the Moon's Shadow (page 56)

Chasing the Shadow: An Observer's Guide to Eclipses, by Joel K. Harris and Richard L. Talcott (Kalmbach, 1994). Everything an eclipse aficionado needs to know to observe a solar eclipse.

"Total Solar Eclipse of 1998 February 26," by Fred Espenak and Jay Anderson (NASA Reference Publication 1383, 1996). This invaluable booklet contains detailed information about the upcoming eclipse – where the partial and total phases can be seen, weather prospects along the path of totality, and tips on viewing the eclipse.

CONTACT

Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187, or to tconley@astronomy.com.

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SHADOW WATCH

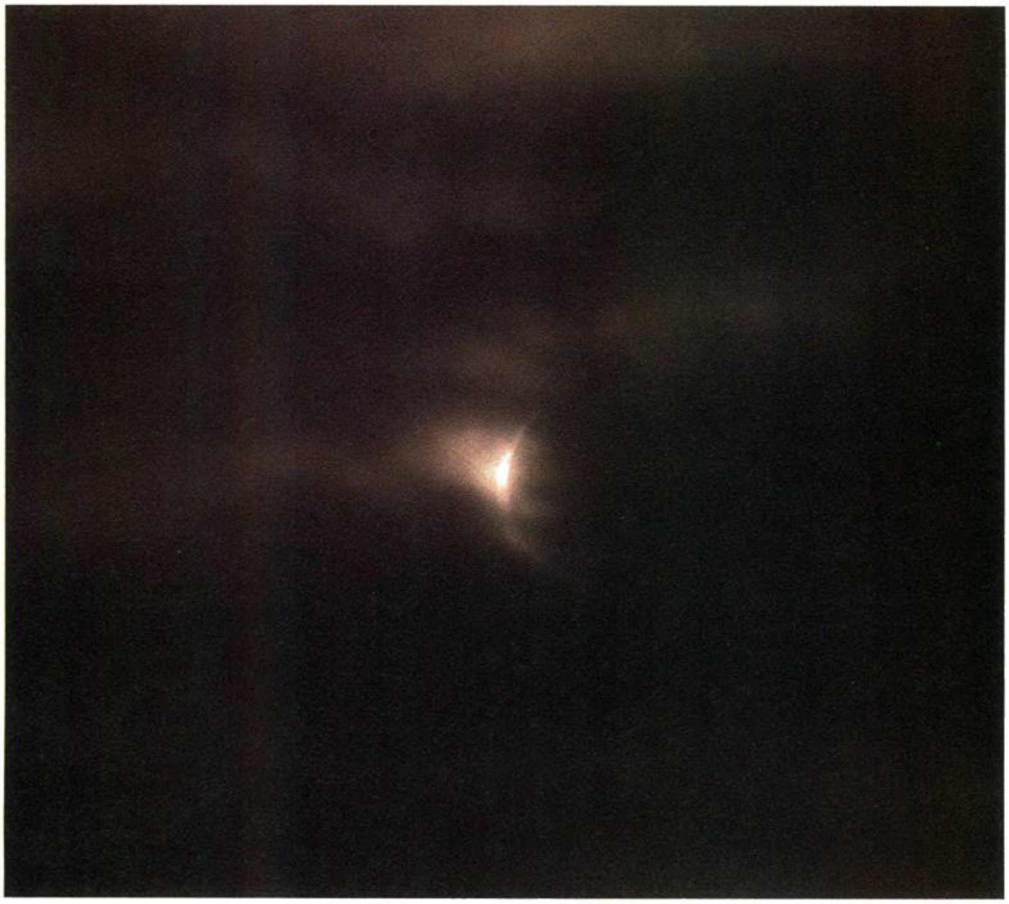
The Eclipse That Almost Wasn't

Clouds threatened to hide totality from eager eclipse chasers in Mongolia

▶ When planning my vacations, I take into account just two variables — the path of the moon and the path of the sun. On one such vacation, a March 1 flight transported me from my hometown of Geneva, Switzerland, to Beijing, China. My window seat on the left-hand side of the plane afforded an all-night view of Comet Hale-Bopp; I was even permitted to venture into the cockpit to point it out to the pilots.

I spent just under a week touring Beijing, meeting up with fellow eclipse followers, obtaining visas to travel to Mongolia, and being entertained by the kite-flying kids in Tiananmen Square. On March 5, the Astronomical League's expedition arrived from the United States. Led by Ken Willcox (co-author of *Totality – Eclipses of the Sun*) and Fred Espenak (of the Goddard Space Flight Center), the group also included people from the Smithsonian Institute of Solar Physics and our youngest member, James Lambert, an eight-year-old who's already seen three total eclipses (in Mexico, 1991; Brazil, 1994; and Thailand, 1995).

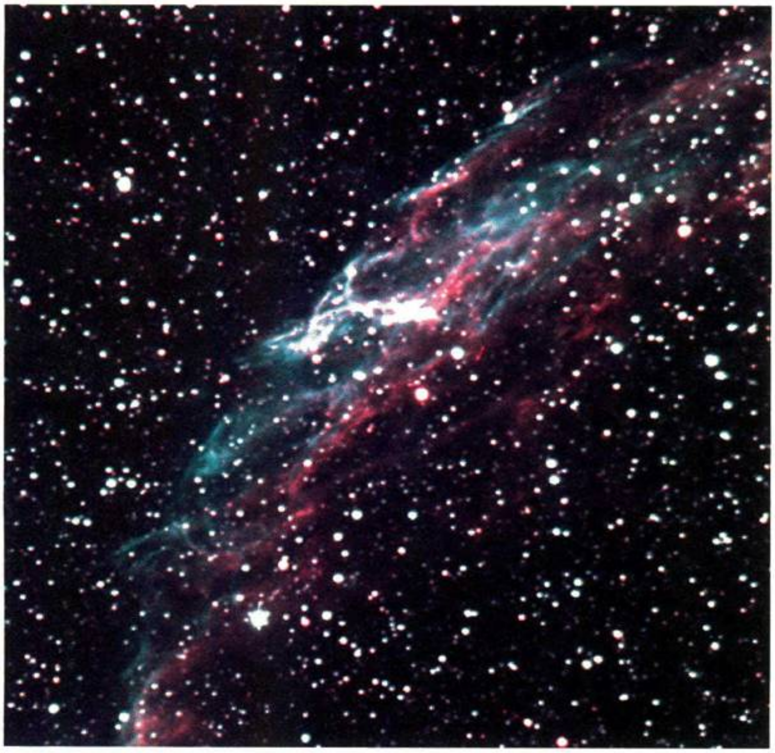
On March 7, we all flew to Mongolia. Eclipse chasers had come from all over the world. On the plane I met more folks, this time from Japan and France. At less



Eclipsed by Clouds in Mongolia

OLIVIER STAIGER

(400mm lens, E100SW slide film, a few minutes before totality on March 9, 1997, taken outside Darkhan, Mongolia)



NGC 6992, a Portion of the Veil Nebula in Cygnus

TIM PUCKETT

(12-inch f/6 SCT, Apogee AP-7 CCD camera, 5-minute exposures in each red, green, and blue) than two days before "E-day," our growing group comprised a multi-cultural menagerie. We spent a night in the gorgeous hotel Chinggis Khan in Ulaan-Baatar, Mongolia's capital, where the eclipse would reach 0.996 percent at totality. We enjoyed views of Hale-Bopp in both the evening and morning skies and spent the day touring museums and Buddhist temples. We boarded a train to Darkhan, about 200 km north of Ulaan-Baatar, in the late afternoon. As the train chugged along, the landscape viewed through the windows was breathtaking; the track snaked alongside a frozen river — we could have skated the entire way.

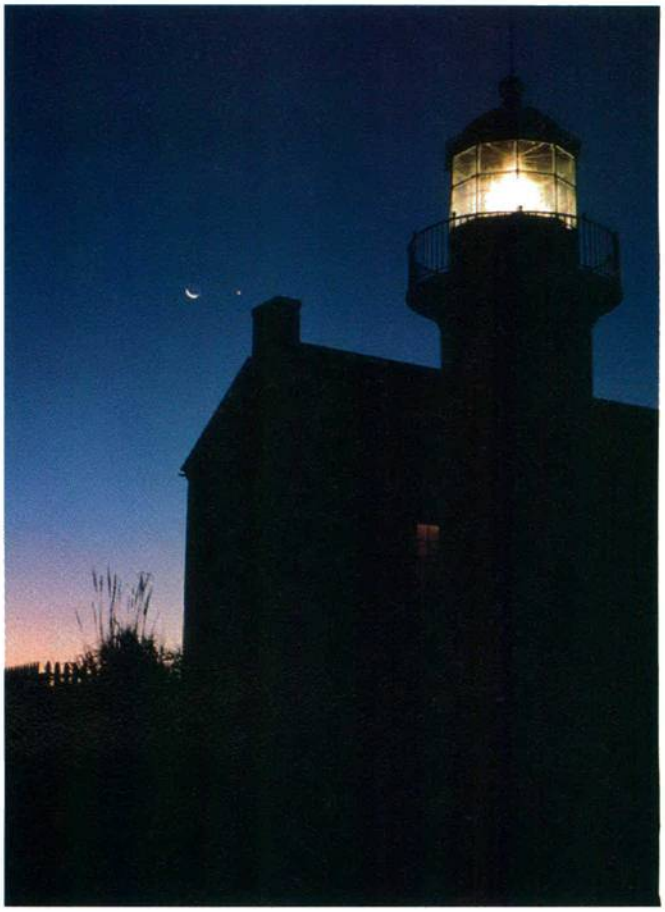
Evening arrived and brought with it bad omens: a solar halo and increasing cloud cover. We arrived in Darkhan and settled in for rest before our early wake-up call. It came at 4 a.m. on March 9, 1997, and to our dismay, the sky was overcast — not a single star could be seen. We dressed warmly and tried to be optimistic. Then a friend's bag, which was full of cameras and video equipment, was stolen, adding to the group's increasingly sullen mood. It began to snow just before daybreak and the 7:30 a.m. sunrise was completely clouded out. First contact of the eclipse, which occured at 7:50 a.m., couldn't be seen. There wasn't a smile in the bunch. At least it was warm, only –5° C.

But then our luck began to change. The police returned the stolen bag of camera equipment. We met them with a standing ovation. At the same time, the clouds opened to reveal the sun, 50 percent eclipsed.

Noctilucent Cloud Banding and the Pleiades

JAY BRAUSCH

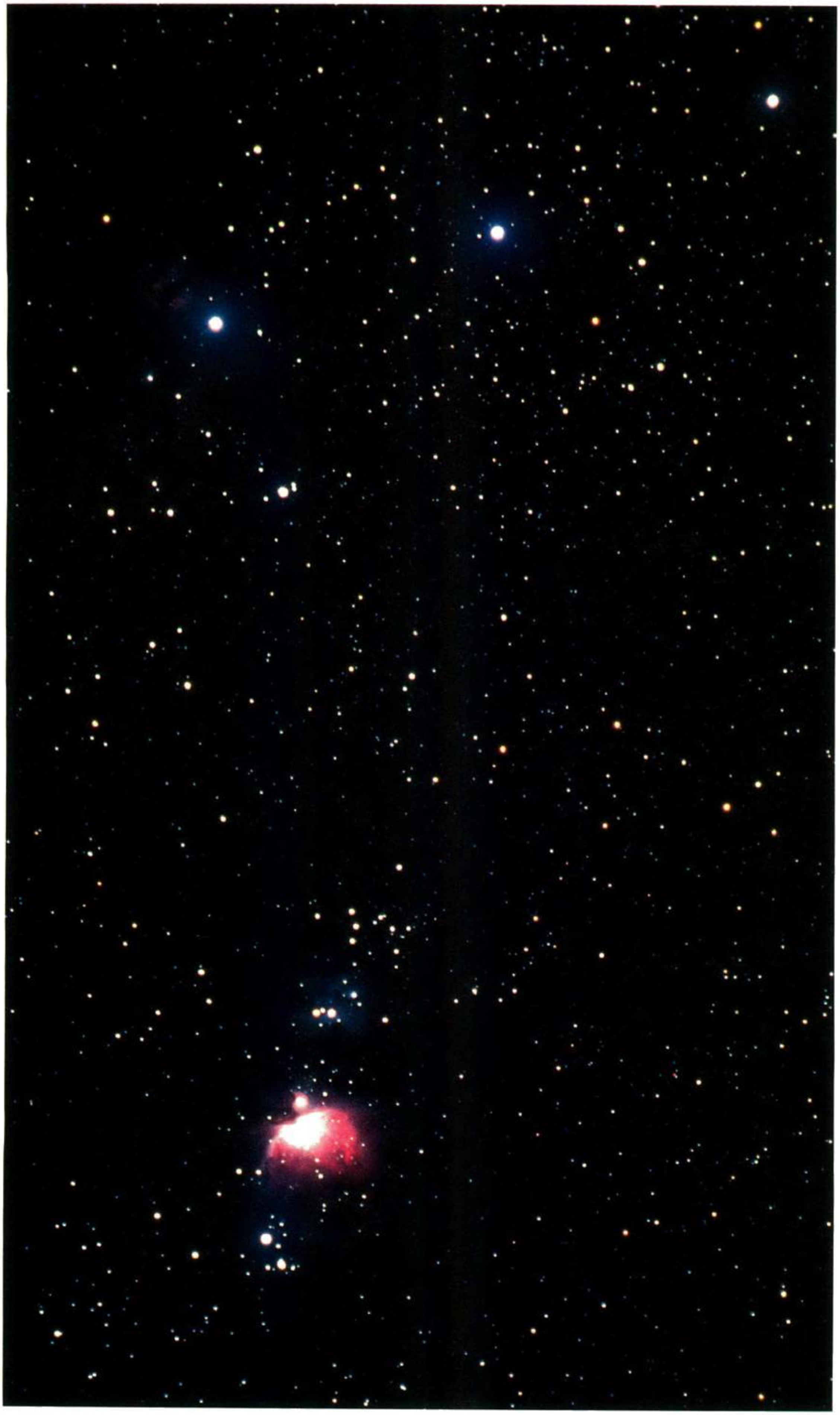
(Taken on June 25, 1997, from Glen Ullin, North Dakota)



Venus and a Crescent Moon above a San Diego Lighthouse

MIKE VOLBERG

(50mm f/5.6 lens, Ektachrome Elite 400 film, ½-second exposure taken December 8, 1996)



The Great Nebula (M42) Glows Brightly

TIM BARNWELL

(300mm f/2.8 lens, Ektachrome 400 film, 6-minute exposure, December 9, 1996)

Hearts began to beat faster as we wondered whether we might get to see a bit of the corona. At 21 minutes to totality some people had started to dance and a crowd of locals had gathered to share the view.

Jupiter and Venus were elusive; we could see just a thin solar crescent. The crescent quickly grew thinner and smaller, and second contact came just one hour after first contact. At two minutes before totality, we could just barely see Bailey's beads, and a cloud hid the diamond ring. Suddenly, the shadow arrived . . . totality!

My tears froze in my eyes. I'd awaited this moment; I'd looked forward to standing in the moon's shadow in northern Mongolia for more than two years.

When the rim of the shadow arrived two minutes and 22 seconds later, it was greeted with applause. Now there were smiles everywhere I turned. Some were disappointed that we weren't able to see Hale-Bopp during totality, but I tried to quiet them with reminders of the opportunities to come: We would get to see Hale-Bopp during the next partial lunar eclipse in just two weeks, and next year's total solar eclipse will offer a great chance to view Comet P/Temple-Tuttle.

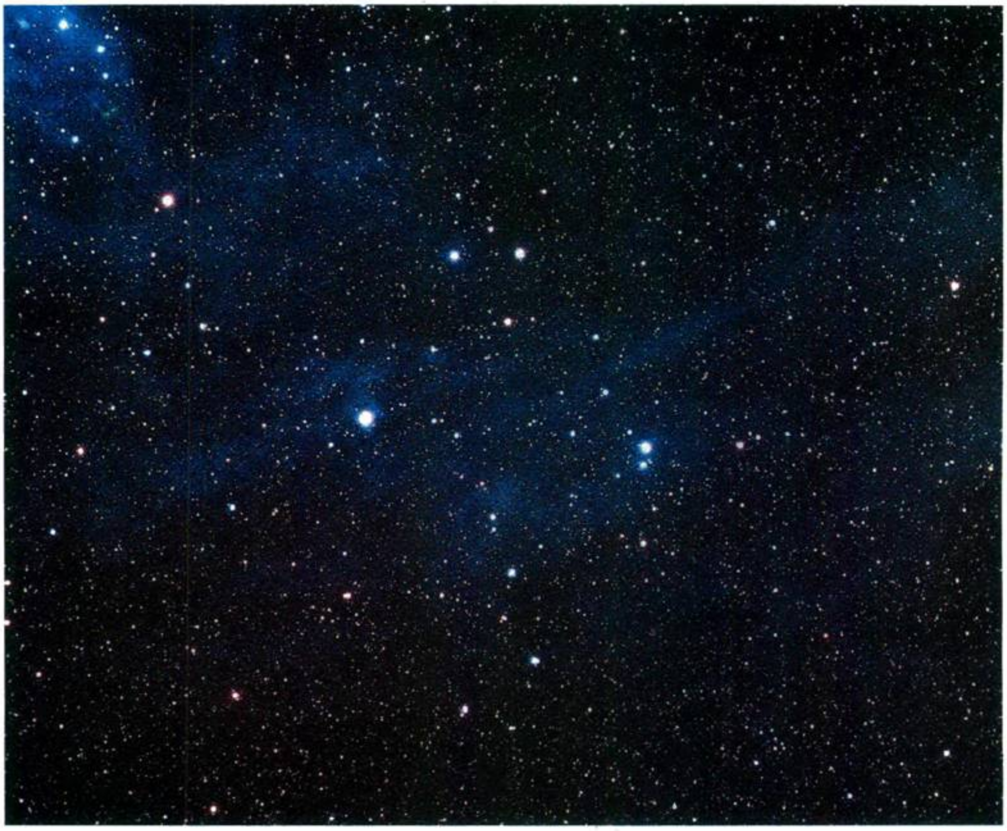
We returned to Ulaan-Baatar and then to Beijing. As I purchased one of the kites I so love from the kids in Tiananmen Square, I reflected on my experiences. This had been an incredible eclipse trip.

Olivier Staiger lives and works in Geneva, Switzerland, when not crisscrossing the globe in pursuit of eclipses.

IC 353 and IC 1995

GEORGE GREANEY

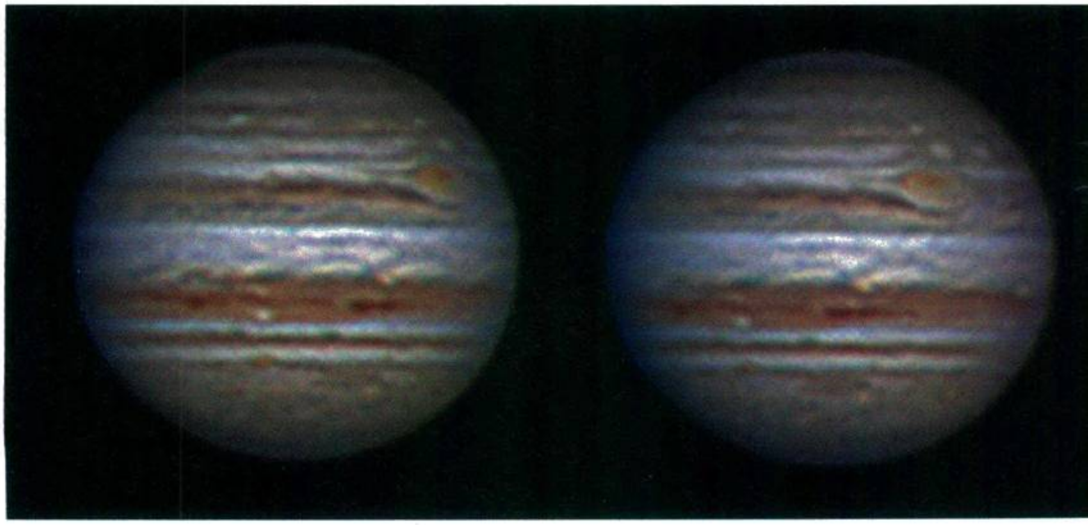
(6-inch f/7 refractor, hypered 120 format Fuji SHG400 film, composite of two 60-minute exposures)



Jupiter's Great Red Spot Rotating on July 14, 1997

DON PARKER

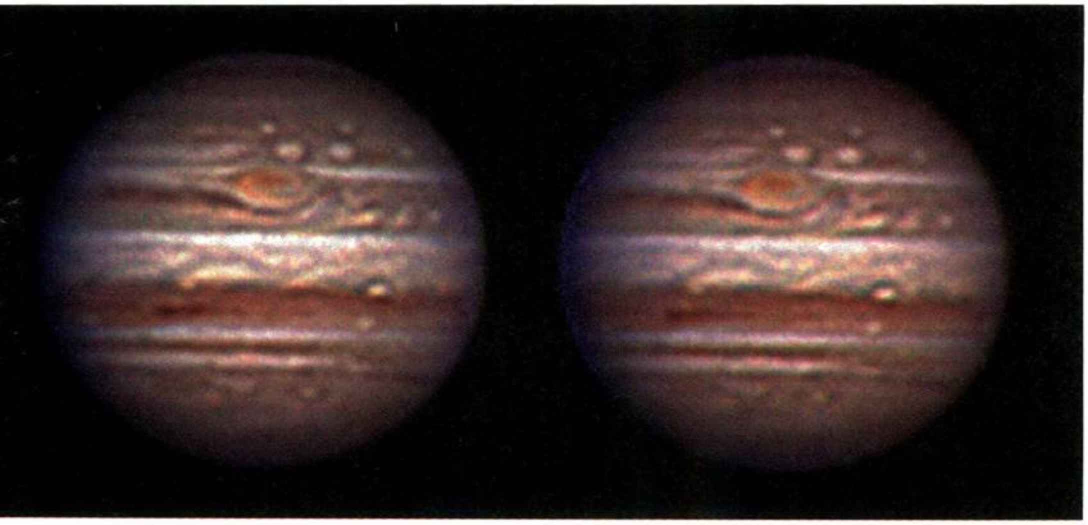
(16-inch SCT at f/19, Pictor 416 CCD camera with infrared rejection filters, composite of a 1.4-second exposure through a red filter, a 1.8-second exposure through a green filter, and a 4-second exposure through a blue filter)

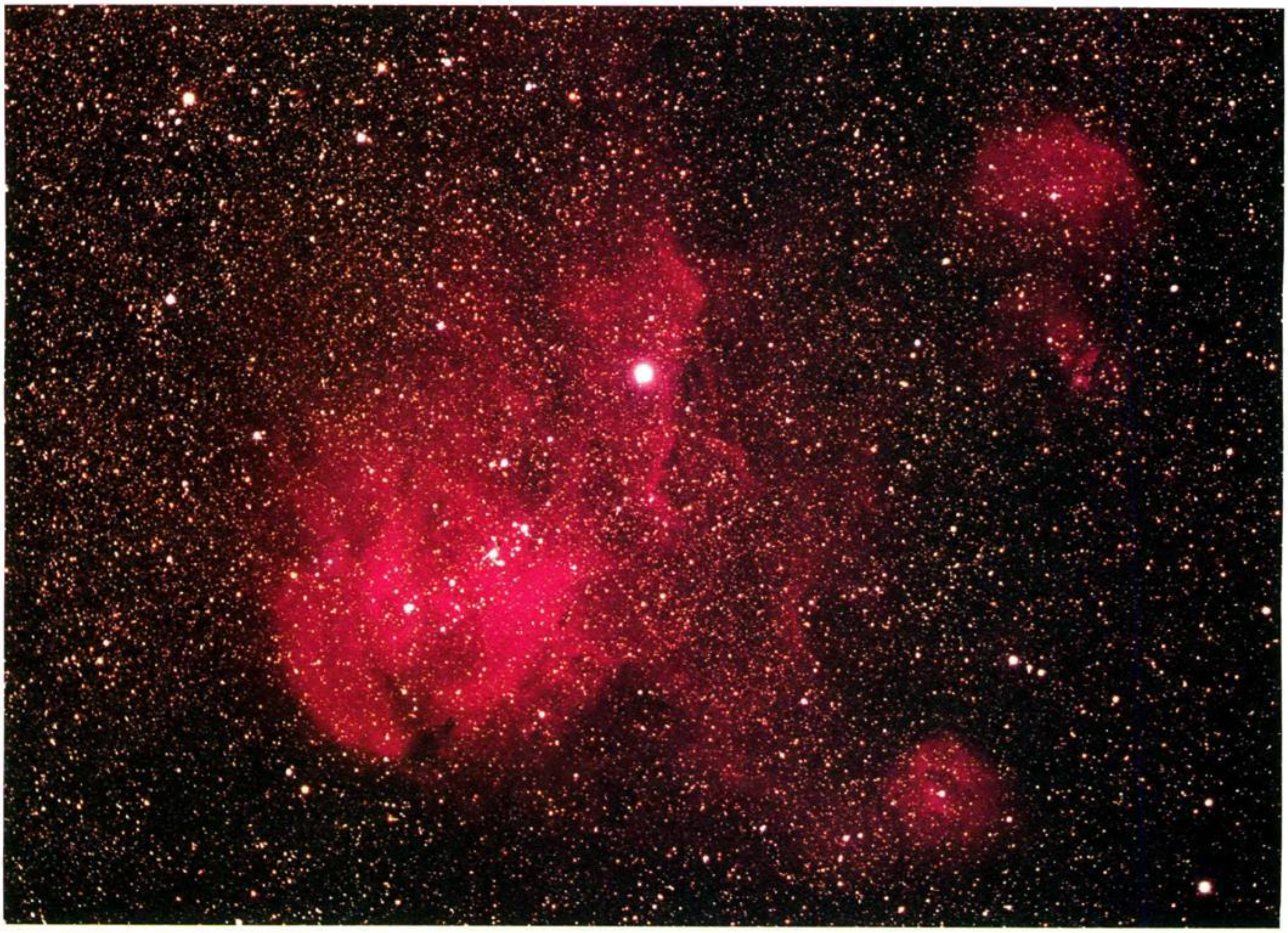


Mars, the Moon, and Venus over the Yellowstone River

JOHN MCNEAL

(28mm f/2.8 lens, Fuji 100 slide film, 20-second exposure taken August 10, 1996)

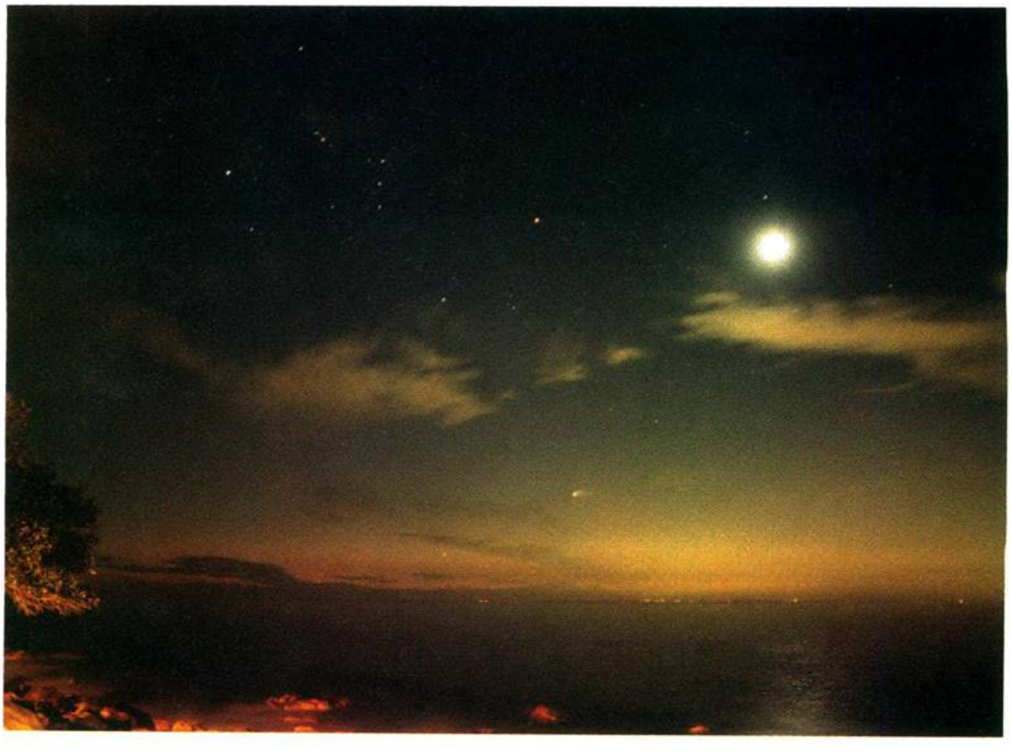




IC 2944 in Centaurus

MICHAEL STECKER

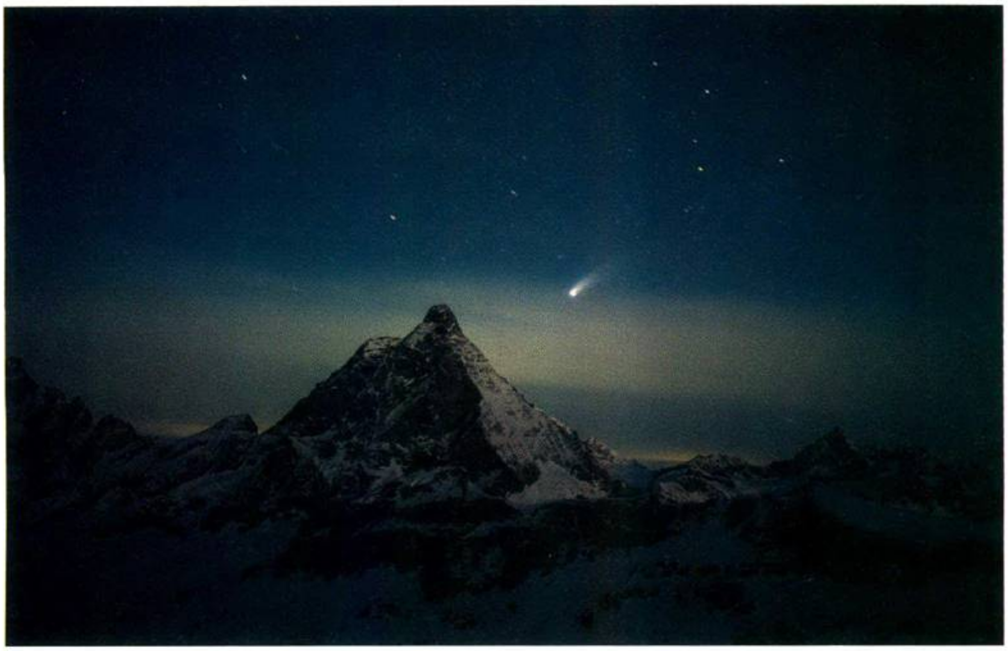
(6-inch f/7 refractor, Fuji Super HG 400 film, composite of two 60-minute exposures)



Hale-Bopp and Orion in South African Skies

JONATHAN BOSHOFF

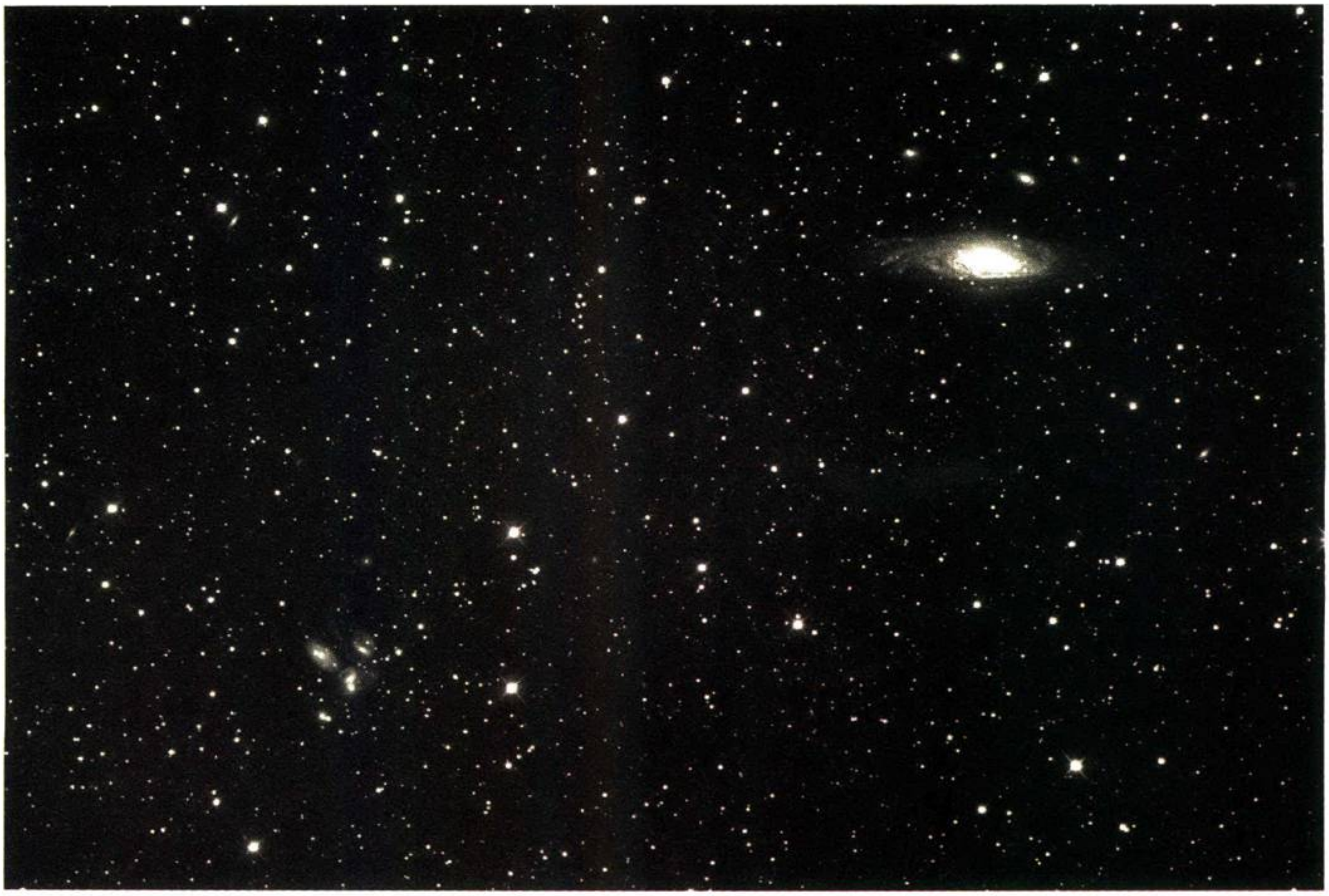
(28mm f/3.8 lens, Kodak Gold 400 film, 15-second exposure taken May 10, 1997)



Matterhorn Hale-Bopp

ANDREA PERO

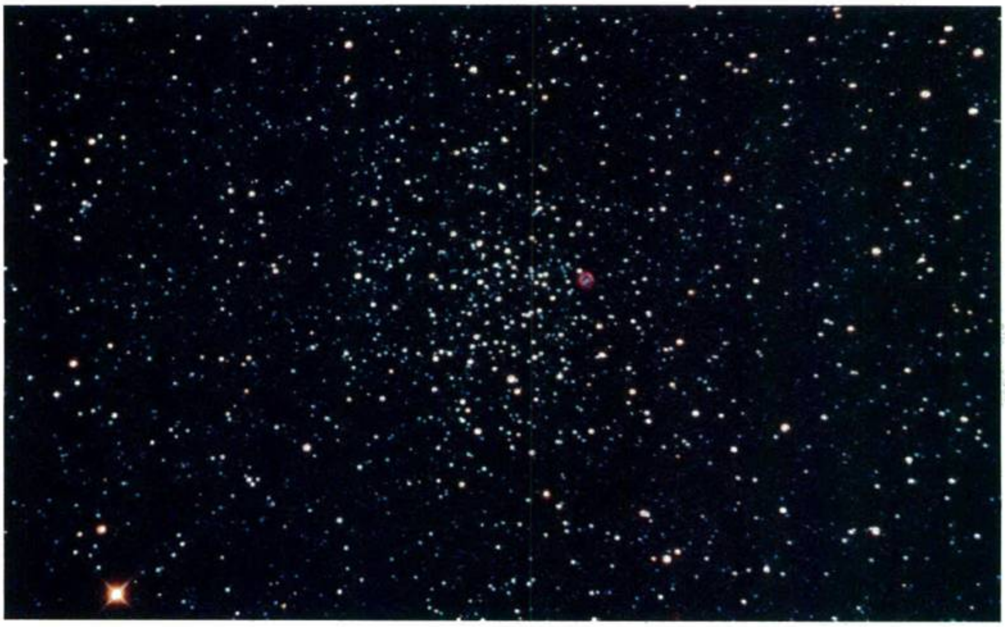
(28mm f/2.8 lens, Kodak PJM 640 film, 90-second exposure taken March 27, 1997)



NGC 7331 and Stephan's Quintet in Pegasus

PRESTON SCOTT JUSTIS

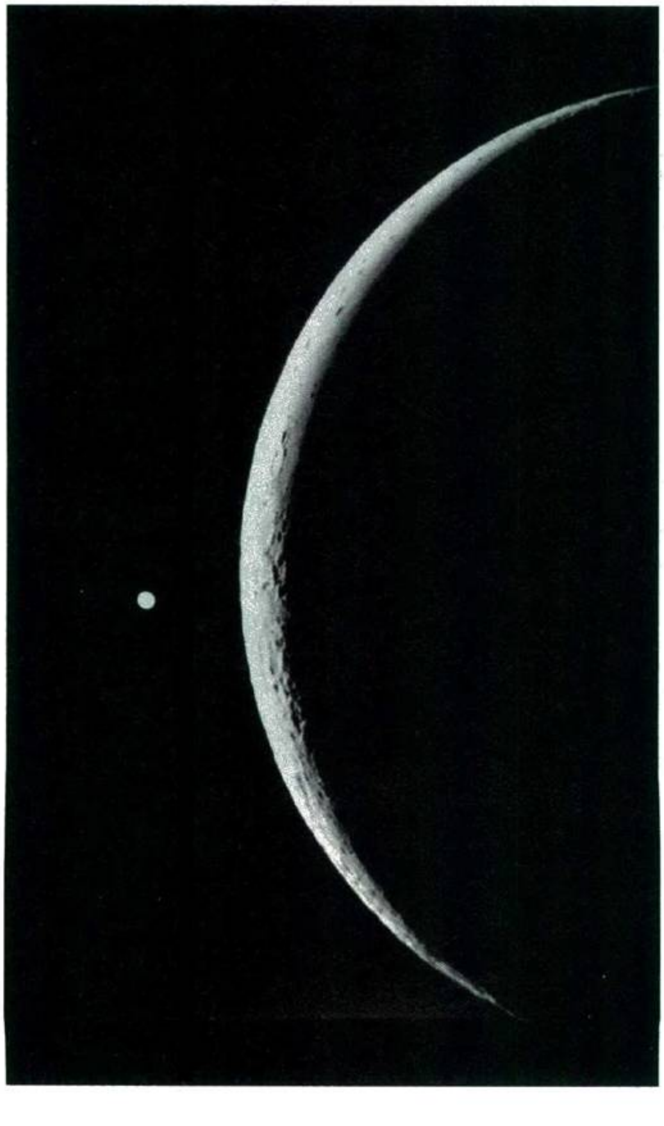
(10-inch f/6 reflector, hypered Tech Pan film, 160-minute exposure)



Planetary Nebula NGC 2438 inside M46

LEE C. COOMBS

(10-inch f/5 reflector, Kodak Ektachrome Professional 1600 film, 20-minute exposure taken January 10, 1997)



The Moon Occults Jupiter and its Moons

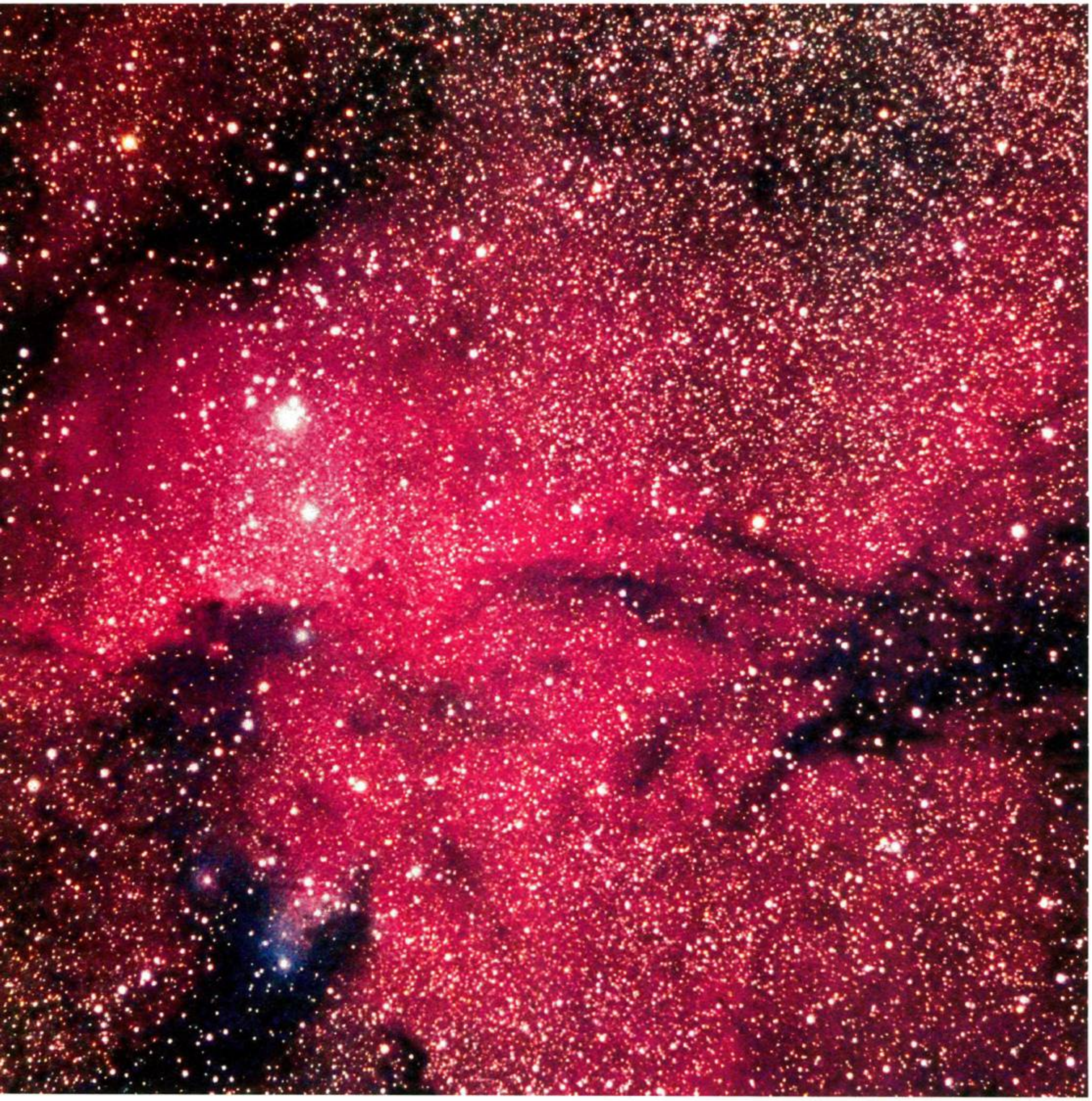
STEVE MICCICHE

(8-inch f/10 SCT, Fuji HG 400 film, 30-second exposure taken October 18, 1990)

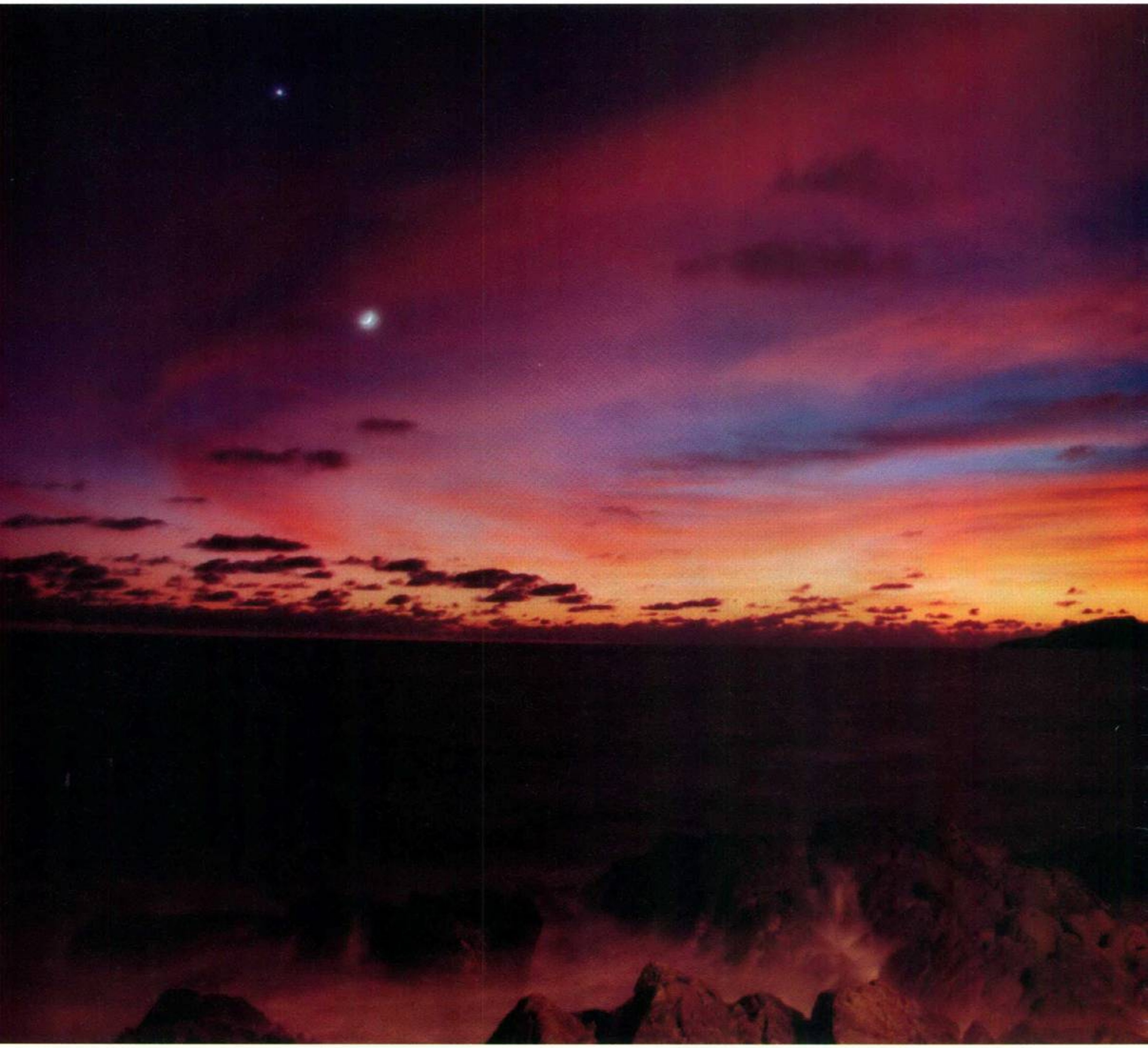
Emission Nebula NGC 6188 in Ara

MICHAEL STECKER

(5-inch f/6 refractor, hypered Fujicolor HG 400 film, 60-minute exposure)



This month's best astrophoto



Sunset, Crescent Moon, and Venus through Mt. Pinatubo Ash

DALE YOUNG

(28mm f/3.5 lens, Kodak Ektar 25 film, 1/30-second exposure)

The ash of the Mt. Pinatubo Volcano in the Philippines, lit by the warm glow of diminishing sunlight, lends an ethereal feel to this spectacular shot of the sky. The crescent moon (left of center) is joined by brilliant Venus (upper left).

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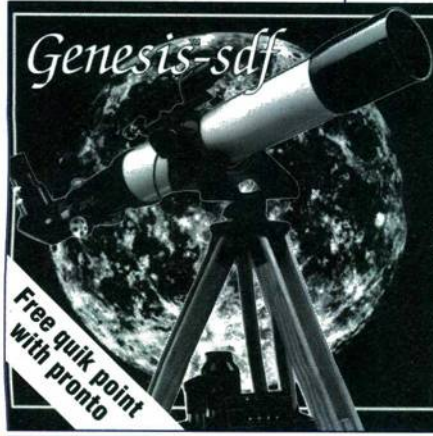

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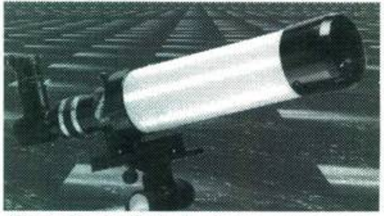

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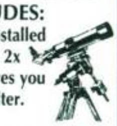

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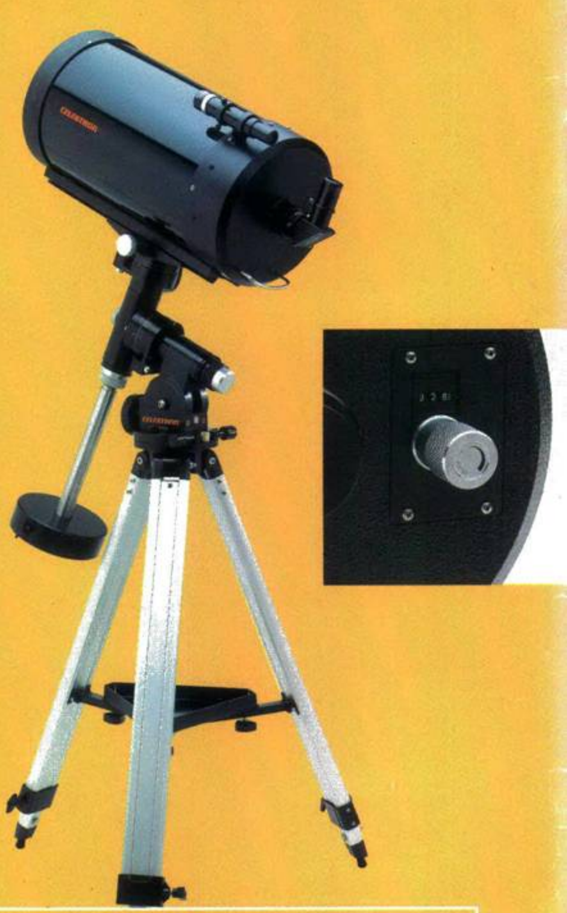

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